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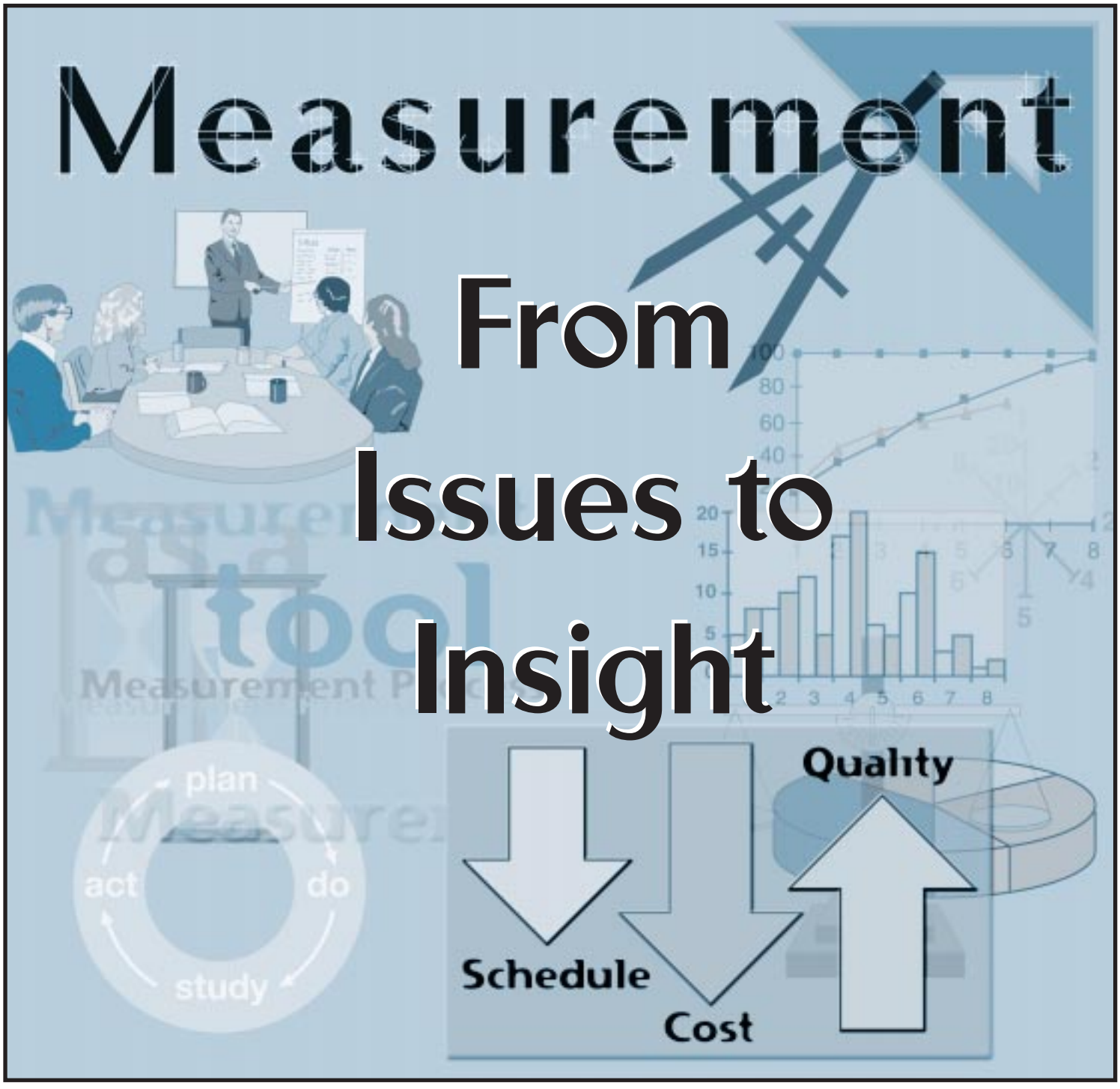

INCOSE
INSIGHT
A PUBLICATION OF THE INTERNATIONAL COUNCIL OF SYSTEMS ENGINEERING

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Subscriptions to *INSIGHT* are available to INCOSE members as part of their membership. Complimentary copies are available on a limited basis. To inquire about membership or a copy, contact Member Services.

Copy Editors: Donna Rhodes, Lori Pajerek, Shirley Bishop

Who are we? INCOSE is a 3000+ member organization of systems engineers and others interested in systems engineering. Its purpose is to foster the definition, understanding, and practice of world class systems engineering in industry, government, and academia. INCOSE is comprised of chapters located in cities worldwide and is sponsored by a corporate advisory board and led by elected officers, Regional Directors, and Directors-at-Large.

From the Editor

Measurement: From Issues to Insight

ISSUES AND INSIGHT. When applied to project and organization specific issues, measurement helps to provide insight that allows decision makers to proactively take actions to effectively control the project cost, schedule, and technical matters. The theme name for this issue of INCOSE ***INSIGHT*** was chosen to emphasize the need to focus measurement on the things that will provide us with the most useful information.

The INCOSE Measurement Working Group (MWG) approach to systems engineering measurement is based on selecting measures to address the project and organization issues and objectives. The process is documented in the INCOSE Systems Engineering Measurement Primer. In developing this approach, the MWG had a goal to ensure that the approach would be consistent with the leading guidance available and the requirements of current applicable standards and capability models.

IN THIS ISSUE. In this issue, we are focusing on how to provide the systems engineering, development, and integration decision-makers with the insight needed to make informed decisions. The articles span the measurement process, from the identification of issues that require insight, through the data collection and analysis that yields the insight to make informed decisions.

In the first article, "Measurement, Models, and Standards," Don Gantzer, Garry Roedler, and Sarah Sheard, present the measurements requirements of current standards and capability models. These affect most system development projects; thus it is important for project managers to understand the measurement requirements of these overarching documents.

The next two articles, "Executive Use of Metrics: Observations and Ruminations" and "An Apocryphal Metrics Case Study: A Composite of Real Experience," provide summaries of lessons learned from multiple organizations. In "Executive Use of Metrics," Dorothy McKinney and Don Gantzer discuss how measurement has been used successfully in organizations in industry and government to support strategic decision making for systems engineering, development, and integration organizations. "An Apocryphal Metrics Case Study," authored by Dorothy McKinney, presents an accumulation of lessons learned from actual experience on multiple projects, in the form of an example case study. These lessons learned are based on actual experience.

The use of good supporting tools can improve the effectiveness and efficiency of any process. To that end, an article by Dr. William Farr entitled "Getting Acquainted With The Measurement Information Systems Tool (MIST)" has been included. This article provides an overview of one measurement tool that has been developed by Naval Surface Warfare Center in collaboration with the INCOSE MWG.

The final article of the measurement focus is "Measurement Process Effectiveness Assessment Framework" by Peter Baxter. It discusses concepts and a candidate approach for assessing the effectiveness of measurement in an organization.

Thus, we have provided a selection of articles that cover the measurement life cycle. For more information on the measurement process and implementation guidance, start with the INCOSE Systems Engineering Measurement Primer. This document can be obtained from the

continued on following page

President's Corner

Bill Schoening, wschoening@inlink.com

Two hundred fifty papers have been submitted for the 1999 INCOSE International Symposium in Brighton, England in June. The SE98 conference sponsored by SESA (Systems Engineering Society of Australia) was held in Canberra, Australia with 140 in attendance. Requests continue to come in for INCOSE to support systems engineering tracks at conferences such as the Software Technology Conference. A new chapter has been chartered in Norway. These are just a few of the signs that INCOSE is growing in strength and international reputation. As we continue to mature during these pre-teen years of our existence, it is important to assess our goals, and the way we are structured and function as means of reaching those goals.

In late October, the Officers and Board of Directors met for three days to examine where we are going and how we are getting there. This was the first step in a longer-term self-assessment. One of the characteristics of good managers, as cited by Dietrich Doerner in his book titled *The Logic of Failure,* is that good managers ask for new data and re-assess their direction on a frequent basis, whereas poor managers tend to use the original data and do little reassessment.

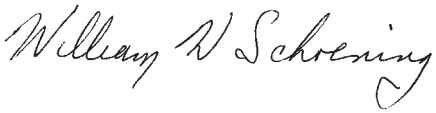
We are not presuming that major redirection is required, nor is there any indication that we need to do so. What is clear is that our international growth is substantial, and this could have a significant impact on everything from the structure of the Board of Directors to the activities we support, such as international and national standards. In addition, we have several challenges that must be addressed for INCOSE to operate in an efficient and comfortable manner. For example, we need to get our Web site up to date and internet groupware operating so that we can better support working groups that are spread across the globe and all time zones.

Donna Rhodes, our new president-elect, is chairing the committee that is doing the preliminary assessment and planning. The Board will take up the challenge during the International Workshop in January, and we will be asking some of you to help in this self-assessment. Additionally, we will be asking others for information and suggestions over the next six to nine months. I trust that you will provide assistance and thoughtful responses when asked; the future of INCOSE depends upon you.

Membership growth is one of the topics of concern. Director Brian McCay is working with the chairs of the membership committee, Lew Lee and Dona Lee, to gain insight into our apparently slow growth rate. Based on initial data, the Board was rather surprised to discover that members who belong for more than one year remain members and seldom drop out. The slow growth seems to be with those who join and leave after a year. We need to understand this trend, and decide how to retain these first-year members permanently. Maybe we shouldn't have been so surprised about the retention of long-term members, considering that about 30 percent of our members attend the International Symposium each year. This is a very high percentage by any standard.

Ken Ptack, Brian McCay, and I represented INCOSE at SE98 in November. I was very pleased with the turn out and the management of the conference. The papers were excellent, and I hope to see some of them presented at the International Symposium in Brighton. In addition, I toured some of the candidate venues for the symposium in Sidney. I think you will enjoy the conference and the city — it is very easy to get around and there was more to do than I could cover in my four day visit. And from a financial perspective, a round trip ticket from St. Louis to Sidney (bought several months in advance) was only slightly more than I paid for a recent round trip ticket to Los Angeles last month. This bodes well for holding the INCOSE International Symposium in Sidney in 2001.

Speaking of symposia, we will be meeting in Brighton, England in June 1999. Brighton is but a few extra flying hours further than those in the U.S. normally travel for conferences. But the trip to Europe may be a surprise to the folks in your organization who fund your trips. It might take them a while to understand that the extra cost is very small. However, the payoff will be substantial in terms of new and different papers, tutorials, and opportunities to better understand systems engineering around the globe. I encourage you to start immediately lining up the support in your organization for you to attend the Symposium in Brighton. See you there!



From the Editor

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INCOSE Central Office. INCOSE members can download it for free from the INCOSE web site. It requires a password that can be obtained from the INCOSE Central Office. The INCOSE MWG also maintains a set of Frequently Asked Questions for Systems Measurement. This can be downloaded for free from the INCOSE website by anyone.

The INSIGHT staff and myself, the theme editor, would like to thank these authors for their contributions to this measurement theme issue. Their willingness to share their experiences, knowledge, and concepts with the INCOSE membership is highly appreciated.

Regards,
Garry Roedler
Theme Editor

Measurements, Standards and Models

Donald J. Gantzer, Co-chair, Measurement Working Group, Garry Roedler, Chair, Measurement Working Group
and Sarah Sheard, Chair, Measurement Technical Committee

Introduction. Practitioners of systems engineering, software engineering, process improvement, and measurement are confronted with numerous standards and models to consider. "Systems Engineering Standards and Models Compared" by Sarah Sheard and Jerry Lake (INCOSE Proceedings, July 1998) discusses many of the current standards and models. To varying degrees, each of these standards and models includes measurements as part of the standard or process model. This article synthesizes some of the measurement implications derived from a few of the more relevant standards and models for systems engineering.

Models and Standards Reviewed
The Software Engineering Institute (SEI) is well known for its series of Capability Maturity Models (CMMs). The most widely used of these models is the Software Capability Maturity Model (SW-CMM). Organizations often implement process improvement vis-a-vis more than one of the CMMs. This requires implementing a measurement program that addresses the explicit and implicit requirements of each applicable CMM and standard. *Practical Software Measurement* (described below) has been a very successful attempt at providing software measurement guidance that meets most of the requirements of the current software models and standards. To address the need for consistent systems measurement guidance, the INCOSE Measurement Working Group is working collaboratively with the Practical Software Measurement initiative to develop Practical Systems Measurement guidance. This guidance is being developed to be consistent with EIA 632, *Processes for Engineering a System,* and EIA/IS 731, *Systems Engineering Capability Model,* as well as ISO 15288, System Life Cycle Process, as it develops. Another effort to address the need for consistent measurement guidance is the development of ISO/IEC 15939, *Software Measurement Process Framework.* The above models and standards are briefly discussed here with an attempt at synthesizing their measurement requirements.

The creators and users of the models have recognized the need for consistent technical guidance. Several groups have integrated technical models and are using them as process improvement frameworks and assessment tools. For example, the FAA has developed its integrated CMM (FAA-iCMM) which integrates three of the SEI CMMs: Software, Systems Engineering, and Software Acquisition (for more information on this effort, see the article by Linda Ibrahim in the November 1998 issue of *CROSSTALK* journal, USAF STSC). The SEI is also undertaking an effort to integrate its capability maturity models. This effort, called the CMM Integration (CMMI) effort, plans to integrate the Software, Systems Engineering, and Integrated Process and Product Development models.

These integration efforts also have implications for the measurement process. The importance of measurement as a required process and communication tool apparently has been recognized in both of these model integration efforts. The FAA-iCMM requires process measurements for all processes at Level 2. The individual process areas require specific measures (e.g., *Project Management* requires size, cost, schedule, and computer resources). In addition, the FAA-iCMM has a separate measurement process area. The CMMI effort currently has a proposal under consideration to include a separate Measurement and Analysis process area that will have capability level aspects starting at Level 2.

Software Capability Maturity Model (SW-CMM)
In synthesizing the measurement requirements and implications of the SW-CMM, common features and activities for each Key Process Area (KPA) were examined for Version 1.1 of the model. Each explicit or implicit instance of measurement was reviewed, categorized, and summarized. Two basic types of measures were noted:

1. Status of activities for every process (a common feature) that includes effort, resources, cycle-time, quality, as well as KPA-specific measures, such as requirements.
2. Specific types of measures required by a KPA.

In general, measures of size, cost/resources, schedule, quality, and risk are needed at Level 2, along with process status measures (e.g., effort, cycle-time, quality, and process unique status measures). As the organization's capability increases, measures are standardized, tailored for project specific needs, and more detailed data is collected to support process characterization and improvement (e.g., efficiency, effectiveness, relationships/root causes, etc.).

The following is a summary of the measurement implications for the indicated levels of the SW-CMM:

Level 2

- *Software Project Planning, Software Project Tracking and Oversight, and Subcontract*

Management KPAs specifically require estimating and measuring size, effort, cost, schedule, computer resources, quality, and risk (examples are also provided for productivity, functionality).
- Feasibility analysis and tradeoff analyses are performed to obtain achievable plans.
- Procedures for planning/estimation must be documented.
- Plans and estimates must be documented and archived along with supporting data.
- Status must be reviewed with the project manager.

Level 3
- The *Integrated Software Management* KPA requires use of the organization's process database for planning and estimating.
- Measurement applies primarily to activities of KPAs for *Integrated Software Management, Peer Reviews, Software Product Engineering, and Organization Process Definition*. These include focus on risk management, training, testing, and functionality.
- More measurement detail is suggested, including thresholds.
- Measures include process compliance measures; measures for estimating, planning and tracking; product measures such as complexity, reliability, and test coverage; and risk analysis measures.

Level 4
- Measurement is integral to the *Software Quality Management and Quantitative Process Management* KPAs.
- Quantitative quality goals are defined from actual historical data and then monitored and revised throughout the life cycle. These are appropriately allocated to the subcontractors.
- The quality of the project's software products is measured, analyzed, and compared to the product's quantitative quality goals.
- Quantitative control of projects and processes is emphasized. Measurement data are planned, collected, and analyzed. Necessary corrective actions are required.
- Statistical Process Control methodology is stressed.
- Additional measurement suggestions are noted for efficiency, effectiveness, quality factors (such as reliability, availability, and maintainability), defects, performance, cost-schedule relationship, and cost of quality.

Level 5
- For the *Process Change Management* KPA, continuous process improvement is the main goal. This requires setting improvement goals and performing detailed estimation and measurement of process changes.
- The Defect Prevention KPA requires institutionalization of defect causal analysis, which drives reporting, and tracking of defects and measurement of process and product quality attributes. Defect prevention data are documented and tracked.
- The *Technology Change Management* KPA drives estimation and measurement of technology impacts and benefits.

Software Acquisition Capability Maturity Model (SA-CMM)

This model focuses on providing a process framework and assessment tool for organizations that acquire software or software-intensive systems. Except for some different KPAs, it is very similar in its measurement requirements. The key difference with respect to measurement in this model versus the SW-CMM is that it explicitly requires "statusing the resultant product" as well as the process, even at Level 2. At Level 3, it specifically requires contractor performance measures. And at Level 4, it requires measurement of the "effectiveness" of the KPAs, not just the "status" of their performance.

Systems Engineering Capability Maturity Model (SE-CMM)

The SE-CMM is a "continuous-view" model, in which each Process Area (PA) is measured separately and given a capability level; there is no overall "maturity level" defined. The capability level of a process is based on conformance with the Generic Practices (GPs) of that level. These are then applied to each Process Area assessed.

In general, Level 2 GPs look at whether the projects plan the process and track with measurements, Level 3 GPs look at whether the projects and organization use "well-defined" data, Level 4 GPs look at whether the organization uses measurement to determine process capability, and Level 5 GPs look at the organization's use of measurement to determine process effectiveness goals. Specific PAs with strong measurement attributes are:

- Analyze Candidate Solutions [schedule and progress, resources and cost, product characteristics, product quality, technology effectiveness]
- Evolve System Architecture [product characteristics, product quality, and technology effectiveness]
- Understand Customer Needs/Expectations [product characteristics, product quality, customer satisfaction]
- Ensure Quality [product quality, process performance]
- Manage Risk [schedule and progress, resources and cost, product characteristics, product quality, technology effectiveness]
- Plan Technical Effort [resources, life cycle cost]
- Monitor and Control Technical Effort [schedule and progress, resources and cost]
- Improve Organization's Systems Engineering Process [schedule and progress, resources and cost, product quality, process performance]
- Provide Ongoing Knowledge and Skills [resources and cost, process performance].

EIA/IS 731: Systems Engineering Capability

The emerging EIA/IS 731 standard, *Systems Engineering Capability,* will replace both the SE-CMM and the INCOSE-sponsored Systems Engineering Capability Assessment Model (SECAM). At the time this article is being written, the model has just received approval and is in the process of being released to the public. Further analysis of measurement requirements for this model will be provided in a future ***INSIGHT*** article. For now, a few additional generalities will be pointed out. EIA/IS 731 is very similar to the SE-CMM in its model structure and measurement requirements. For example, at Level 2 (Managed), Generic Practices require planning projects, verifying compliance and tracking to approved plans and processes, and taking appropriate action when performance deviates from plan. Capability progression to higher levels is performed on a process-by-process basis, as is the case with all continuous models. In addition to the determination of capability level of a process (called Focus Area), EIA/IS 731 has "generic attributes" that are used to assess the effectiveness of the process and the value of its products. For example, criteria at Level 2 are considered "adequate" if effort expended and the resulting products provide "reasonable benefit." The only measures that are specifically indicated by EIA/IS 731 are effort, cost, schedule and other critical resources. Other measures depend on the processes defined and the project's or organization's implementation of those processes.

ISO 9001

This international standard for quality systems is well established, and therefore worth briefly reviewing here. There are no capability levels defined in this standard, since it is not meant to be a capability model. It is a compliance standard that includes requirements focused on implementing a quality system. Of the twenty quality elements in this standard, those most related to measurement are:

- Management [quality objectives]
- Quality System [planning and performance]
- Design Control [record design verification measures]
- Document and Data Control, Process control [process parameters, product characteristics]
- Control of Inspection/ Measuring/Test Equipment [measures and records]
- Corrective & Preventive Action [magnitude, risks, effective action]
- Internal Quality Audits [effectiveness]
- Statistical Techniques [process and product, documented procedures]

EIA 632: Processes for Engineering a System

This standard defines thirteen processes for engineering a system and thirty-four requirements. Measurement is an implicit requirement of much of the standard, in order to address these defined processes and requirements. Some of the items in this standard that need the greatest use of measurement are:

- Acquisition
- Supply
- Planning
- Assessment
- Control, Solution
- Systems Analysis
- Requirements Validation
- Product Verification and Validation

Typical measurements noted are effort, schedule, cost, performance, effectiveness, tradeoff parameters, and risks. When it is released, EIA/IS 731 will be consistent with EIA 632.

ISO/IEC 15939: Software Measurement Process Framework

As an outgrowth of the inconsistent and disjoint measurement guidance in existing engineering standards, a new standard is under development. This emerging standard, ISO/IEC 15939, *Software Measurement Process Framework,* is focused on providing common terminology and a framework for the communication of measurement information (see paper presented by Dave Card and Khaled El Emam at the PSM User Group Conference, July 1998). It defines the measurement process in a typical process cycle as is illustrated in Figure 1.

Figure 1: Measurement Process Framework

The *Establish, Plan,* and *Perform* steps of this process are very similar to and consistent with the *Tailor, Apply,* and *Implement* steps defined by the Practical Software Measurement (PSM) guidance. The framework further addresses many of the generic processes defined in other models and methodologies, such as obtain commitment and resources, and evaluate and improve the measurement process. The *Evaluate and Improve* steps of this process address the need to look at the effectiveness of the measurement process itself and to take actions to improve measurement effectiveness. This framework appears to be very adaptable to systems measurement.

Other Standards

There are many other standards in the systems and software engineering community that have explicit or implicit measurement requirements (see http://www.software.org/quagmire for an overview of these standards and related links). Those reviewed above are only a sample that are of interest to a wide and more general audience. There are many other standards with significant measurement requirements that are focused on a specific technical aspect of the system or its software. For example, ISO 9126, *Information*

Technology – Software Quality Characteristics and Metrics, has significant measurement requirements, but focuses specifically on the quality characteristics of the software developed. There are too many standards across the multiple standards organizations to examine all of the requirements in one article.

The next section will discuss available measurement guidance that can help a project or organization determine what to measure, how to measure it, and how to analyze the measures and use the results to meet the requirements imposed by any of these models and standards.

Addressing the Measurement Requirements of the Models and Standards

Software Measurement. The Practical Software Measurement (PSM) initiative has developed measurement guidance focused on helping projects implement measurement, and that provides insight into the specific issues of their software development throughout the life of the project. The PSM initiative is sponsored by the Office of the Under Secretary of Defense (OUSD) and includes development and transition support from government, industry, and academia. The PSM guidance includes common software issues with associated measurement categories, and candidate measures that can be very useful for aiding projects and organizations in meeting the measurement requirements of the SW-CMM, SA-CMM, and the standards. The following list shows the common issues and associated measurement categories (refer to the PSM guidebook for information regarding the candidate measures–available at http://www.psmsc.com):

- Schedule & Progress [milestone performance, work unit progress, incremental capability]
- Resources & Cost [personnel, financial performance, environmental availability]
- Growth and Stability [product size and stability, functional size and stability]

Table 1: Practical Systems Measurement Common Issues, Measurement Categories, and Candidate Measures

ISSUE	CATEGORY	MEASURES
Schedule and Progress	**Work Unit Progress**	Problem Report Status
		Management Tracking Status
		Element Status
		Requirements Status
		Life Cycle Activity Status
		Reviews Completed
		Change Request Status
	Milestone Performance	Milestone Dates
		Schedule Dependencies
		Lead/Slack Time/Critical Path
	Incremental Capability	Delivery Content – Elements
		Delivery Content – Functionality
Resources and Cost	**Personnel**	Effort
		Staffing
	Financial Performance	Cost
		Earned Value
	Environment and Other Resources	Resource Quantity
		Resource Availability
		Resource Utilization
Product Characteristics	**Functional Size and Stability**	Requirements
		System Functions
		Requirements Added, Deleted, or Changed
		Requirements Traceability
	Product Size and Stability	Elements
		Interfaces
		Database Size
		Physical Characteristics
Product Quality	**Functional Correctness**	Problem Reports
		Defects
	Efficiency	Throughput
		Utilization
		Time
	Reliability	Failures
	Usability	Learning Difficulty
		Operational Errors
		Customization Difficulty
	Maintainability	Maintenance Times
		Maintenance Actions
	Portability	Open Systems Compliance
Process Performance	**Process Evaluation**	Capability Level
		Audit Findings for Processes or Plans
	Process Efficiency	Productivity
		Cycle Time
	Process Effectiveness	Effectiveness of Process Tasks
	Rework	Rework Size
		Rework Effort
Technology Effectiveness	**Technology Maturity**	Technology (or product) Stability
		Relative adequacy for application
	Technology Impact	Technology implementation impact
		Functionality covered by a specific technology
Customer Satisfaction	**Customer Feedback**	Award Fee Amounts
		Survey Results
		Number of Commendations/Complaints

- Product Quality [defects, complexity, rework]
- Development Performance [process maturity, productivity]
- Technology Adequacy [technology impacts, technical performance, target computer utilization]

Systems Measurement. For both the SE-CMM and EIA/IS 731, the measurement requirements are addressed very well by the emerging "Practical Systems Measurement" common issues and candidate measures for systems. This is currently being developed collaboratively by the INCOSE Measurement Working Group and the Practical Software Measurement initiative. These issues and measures are being integrated with the PSM common issues and candidate measures for software. Table 1 contains the current list of common issues, measurement categories, and candidate measures under development by this effort.

Measurement Capability Summary

Synthesis of these standards and models is captured in the Measurement Capability Summary (MCS) shown in Figure 2. It is a starting point towards the development of guidance to support measurement improvement needed as organizations improve their capability levels for the models reviewed above. Further development of this guidance will be an ongoing activity of the MWG. Comments and suggestions are welcome and should be directed to the authors.

Summary & Conclusions

In summary, the models and standards collectively require measurement to focus on aspects of projects (and organizations at higher capability levels), products, and processes. Measurement itself is a process that, in turn, needs to be integrated with other processes in order to efficiently and effectively measure those processes and their products. Being a process, measurement also needs to be analyzed for process improvement opportunities that make the measurement process more effective and efficient.

Clearly, the standards community has recognized the importance of measurement for process and product planning, control and improvement, and that there is a need for some unifying principles, standards and models for measurement. The capability model integration activities are attempting to move ahead on this front. As these efforts continue, the INCOSE MWG will track, participate in, or influence as many of these efforts as possible.

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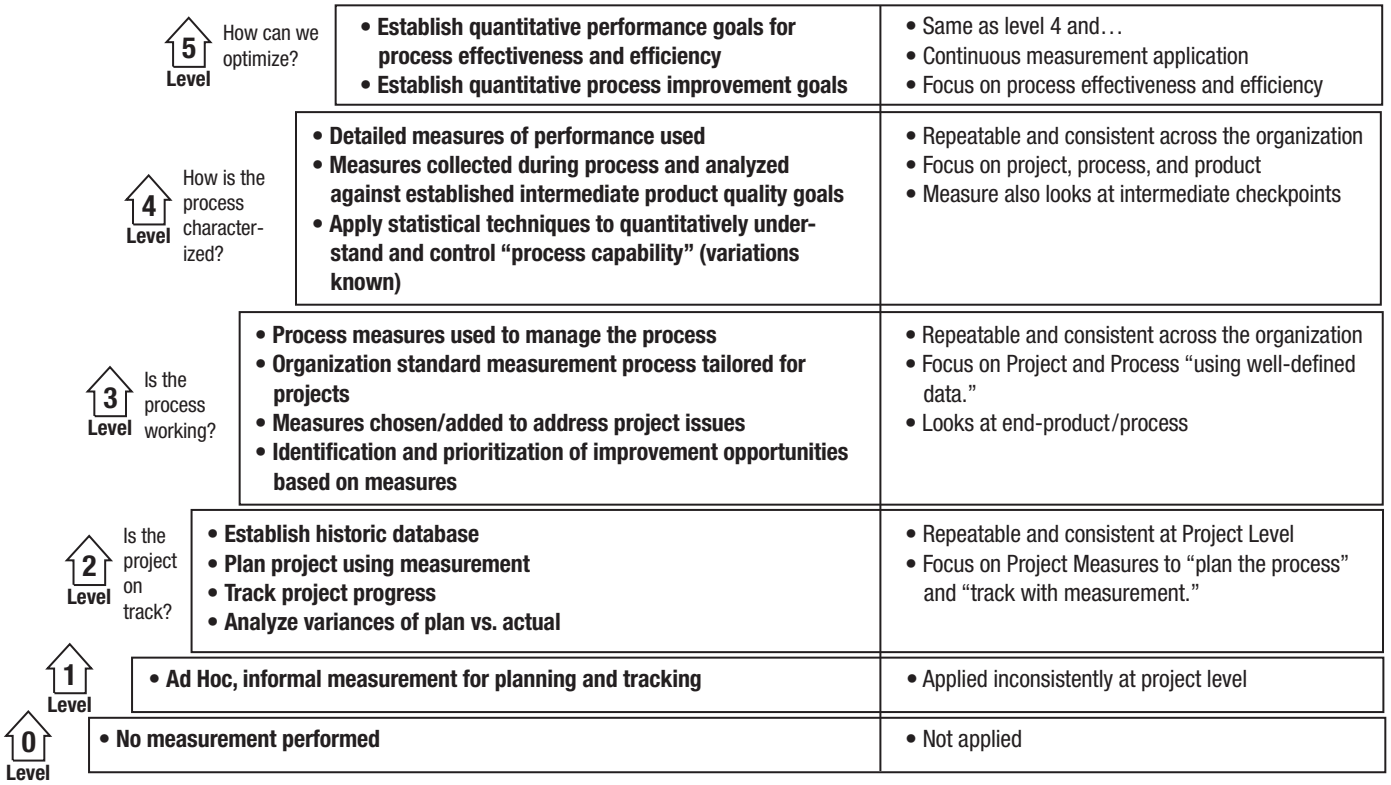
***Garry J. Roedler** *(garry.j.roedler@lmco.com) is a Principal Systems Engineer at Lockheed Martin Management and Data Systems, where he is the Chair of the Systems Integration Process Review Board. Garry is also the project lead for the Practical Systems Measurement project.*

****Sarah Sheard** *(sheard@software.org) is a Senior Systems Engineer at the Software Productivity Consortium where she works with member companies on definition, implementation, and improvement of systems engineering processes and measurement.*

The information contained herein does not necessarily represent views of TRW, FAA, Lockheed Martin, nor SPC.

Figure 2: Measurement Capability Summary



Executive Use of Metrics: Observations and Ruminations

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Introduction. Metrics can help to improve our ability to understand, manage, implement and improve systems engineering efforts, and the projects they support in several ways. Metrics provide insight into the status and progress of tasks, can provide intimations of the potential prospects, and can provide indicators of when changes in implementation plans are needed to achieve success. Anecdotal evidence suggests that the most effective use of metrics in systems engineering to date has been primarily at the working level and its immediate management. Although the potential for effective use of systems engineering metrics by executives has been identified, and most metrics practitioners have an intuitive sense that metrics could significantly enhance executive effectiveness, little use of systems engineering metrics has been made at the executive level. The purpose of this article is to share some observations of the authors related to executive use of systems engineering metrics, and to share our thoughts on how organizations might be able to support more effective use of systems engineering metrics by executives.

The authors have had the opportunity to observe use of systems engineering metrics by executives in several organizations, including our customers and prime contractors, our co-contractors and subcontractors, our suppliers, and collaborators in industry associations, as well as the organizations in which we have individually worked. So the observations we share here do not necessarily reflect any specific characteristics of our current employers.

Executive Metrics Versus Project and Systems Engineering Metrics

Perhaps we should begin by describing what we mean by an executive. For the purposes of this article, we take "executive" to mean someone who is a member of the small team of people who typically are responsible for running an enterprise. In this context, an enterprise is an organization, or somewhat autonomous unit of a larger organization, which is responsible for developing its own strategy and implementing tactical plans and activities to fulfill this strategy. For example, an enterprise, for the purposes of this article, would be a profit center within a profit-making company, or an agency or bureau responsible for a specific mission within a public organization.

The essential characteristics of an executive, for the purposes of this article, which distinguishes him or her from a systems engineering manager or a project manager are:

- An executive is responsible for the long-term health and viability of the organization, in addition to the successful completion of current projects.
- An executive is responsible for selecting and managing the people who lead the efforts on current projects.
- Although concerned about the success of individual projects, the executive is not typically involved with actual task execution on individual project tasks; instead he or she get information about project progress, prospects and problems from managers on each project.

Given these characteristics of an executive, it is easy to see the potential benefits to executives of using metrics. Metrics can provide a systematic source of information on project progress that can potentially be less influenced by the bias of lower-level managers and individual contributors than qualitative status reports may be. Metrics may be able to provide input on the quality of the understanding of the real problems on the projects that lower-level managers have, so executives can more effectively choose where to focus their efforts. These efforts would then include coaching and mentoring their subordinates, providing resources, assigning responsibility, and sharing historical information, as necessary to improve performance. Metrics may also be easier to compare across multiple projects than qualitative status, and thus may form a better basis for decision-making about issues relevant to the long-term health and viability of the enterprise. Common measures from across projects can also form a better basis for estimation and planning for future projects. But in fact it is rare to see executives use metrics for these purposes. The remainder of this article explores some of the reasons for this lack of effective metrics use by executives, and some ways organizations might be able to make it more likely that metrics can and will be used effectively by their executives.

Issues with Executive Use of Metrics

To be fair, we should begin by observing that most executives do make very effective use of some metrics, especially cost-related metrics: budget, schedule, expenditures to date, estimates of cost and schedule required to complete a project. In most enterprises, management information systems exist which provide regular information about expenditures, and often about achievement of schedule milestones. The more effective these management information systems are in providing timely, accurate data, the more likely it is that the executives who use this data will understand

the potential of metrics as one good basis for managing the enterprise.

Why don't executives who find cost and schedule metrics useful demand additional metrics from the people who work for them? One reason is that the current metrics, such as earned value, may not be correctly and consistently collected and used within the enterprise, perhaps because they are not well understood or clearly defined at lower levels in the organization. When executives see unusable metrics (even ones whose potential value they clearly understand), they often conclude that additional metrics would provide no useful additional insight. A second major reason that executives do not ask for metrics is that they do not understand what they should do with the metrics when they get them.

There is one other reason that some executives do not demand more metrics data: They do not clearly understand what success means in terms of the actions of their organization. All executives understand quite well what success means in terms of outcome variables — achieving targets for sales, profits, and cash flow in profit-making companies, or achieving targets for services provided within available budgets for non-profit or public organizations. But far fewer executives truly understand what actions and results within their organizations are needed to add up to success for their enterprise—that is, the combination of factors which will enable their enterprise to meet its short-term commitments, while enabling its long-term survival and prosperity. In our observation, the very few executives who do make extensive use of metrics to run their enterprises effectively have a unique vision of how their organization needs to operate to succeed, and an ability to translate this vision into targets for every aspect of the organization. This goes far beyond costs and schedule and systems engineering metrics. It could include, for instance, staff turnover metrics, metrics on acquisition and upgrading of staff skills, extent of risk-taking across the enterprise, extent of innovation across the enterprise, extent of reuse of technology of product elements between successive projects, and so on. None of these metrics in isolation determines the health of an enterprise, but, taken together, such metrics can tell an executive how well the enterprise matches his or her vision of how the enterprise needs to function to succeed.

For executives to make effective use of metrics, then, they need to understand what metrics they should look at, understand which values of the metrics are expected (and thus require no action on their part), and understand what actions they should take for values of the metrics which are outside the expected. In practice, this works best when the executives also understand how a set of metrics, taken together, reflects the status and prospects of a project. Finally, it is important that the executives use, rather than abuse, metric data, because metrics will be reported honestly only when they are not used to punish the people who provide them.

So, the bottom line of this discussion is that in order to enable executives to make effective use of systems engineering metrics, we probably should not wait for the executives to ask for specific systems engineering metric data. Rather, we should identify what use they *could* make of systems engineering metric data, and offer them both the data, and our insights into how it can be used to enable them to do their jobs more effectively. Obviously, this requires some tact on our part, because few executives welcome advice from their underlings on how to do their job better. But many executives will indeed warmly welcome better information on which to base their decisions, so this is how we need to present our systems engineering metrics if we want them to be used effectively by the executives who run the enterprises in which we are working.

From our own observations, and the insights our colleagues across industry have shared with us, several common themes emerge from the anecdotes of ineffective use of systems engineering metrics by executives. The first theme is that a single metric in isolation can lead an executive to focus on the wrong things for project success. For instance, reporting requirements volatility to executives often results in direction to project personnel to get the requirements firmed up, and to resist customer efforts to change requirements, especially as a project moves from requirements analysis to design to implementation. However, for a project on which the buy-in of key customer stakeholders has not been obtained, requirements volatility may be a symptom of this lack of buy-in, rather than of a lack of closure in the systems engineering process. So casting requirements in concrete may enable your enterprise to develop a system which can be sold off to the customer as meeting contractual requirements, but which will never actually be used for the intended purpose because it doesn't meet critical end-user needs. Or, on a project where leading edge (or bleeding-edge) technology is being used, requirements changes may reflect an education process on the part of both the enterprise and the customer community about what is feasible and desirable to make effective use of the new technology. Casting the requirements in concrete may result in the development of a system which is unworkable (too awkward to use, too expensive to maintain, etc.). Numerous lesson-learned briefings developed after the completion of projects have shown us that merely decreasing requirements volatility, by itself, is no guarantee of project success. But unless executives are given the additional information they need to understand the real nature of the problem(s) facing a project, giving them data on requirements volatility may lead them to take action to reduce this volatility, thinking that they are helping the project succeed.

The second theme is that when the metrics being used to manage at

lower levels are given directly to executives, they are either ignored or misused. When executives are given systems engineering metrics data that show a need for action, they either need to take that action themselves, or be confident that their subordinates are in the process of taking that action. If executives get the metrics that lower-level managers are using to manage, together with a description of the actions taken in response to the metrics which are outside of their control limits, the executives get the implicit message that the metrics are for their information only. Their lower-level managers are using the sharing of metrics data and their action plans as a way to showcase their own management prowess. Of course, some executives still use this data as a basis for action on their part—and often end up second-guessing or micro-managing the managers under them. If executives get systems engineering metrics data that show a clear need for action on the part of their subordinates, and they get no indication that their subordinates are taking action, they will often either try to do some part of their subordinates job for them, or reduce the amount of responsibility they give that subordinate. Common sense would suggest that the executives should ask subordinates what action they are taking before taking action themselves. But often, information showing a need for action, coupled with a lack of clear evidence that the lower-level manager is taking appropriate action, is enough to galvanize an executive into personally doing something about a problem.

So, in order to be a good basis for executive action, systems engineering metrics given to executives need to be:

- **composite**, combining all of the related lower-level systems engineering metrics into one higher-level metric with control limits that clearly show when action on the part of the executive is appropriate;
- **forward-looking**, encompassing not only the status of systems engineering metrics at present, but also the magnitude, direction and speed of changes in these metrics which can reasonably be expected as corrective actions initiated by lower-level personnel and managers are implemented;
- **putting problems and risks in perspective**, by reflecting the degree to which the resources available to project personnel are insufficient to achieve project goals (since one useful function the executive can perform is to make additional enterprise resources available to the project if those resources are critical to project success).

Some Guidelines and Lessons Learned on Executive Use of Metrics

As described in *Practical Systems Engineering Metrics*, use of systems engineering metrics seems to be most effective when the metrics reflect the specific priorities and challenges of the individual project on which they are being used. Metrics also seem to be most effective when:

- they are collected as a routine part of executing project tasks, rather than as an additional activity;
- people contributing to the metrics understand that the metrics will be used to improve project implementation, rather than to judge the comparative performance of individuals (in other words, they won't be used to mete out punishments or rewards);
- the metric measures something over time which is not intuitively obvious to all of the participants in the project and the enterprise (if the metric just restates the obvious, it doesn't have much added value);
- the normal, expected range of values for the metric is understood (so users of the metrics can see at a glance if the metric shows that action or investigation is needed). Note that early use of a metric may need to be done without expected ranges, since realistic values of the metric may not be understood. If this is the case, it is important to use the metric for information, and not for action, until expected ranges are understood;
- the locus of responsibility for taking action based on the metric is clear and unambiguous (so the use of metrics doesn't lead to micro-management caused by multiple layers of management trying to solve the same problem simultaneously).

For systems engineering metrics, the last two points mean that the same metrics used by systems engineering staff and their immediate managers are not generally suitable for use by executives. This is because the values of the metrics which should trigger an executive action are not the same as the values which should trigger action by systems engineering folks, and because we do not want to ask executives to solve problems that systems engineering managers under them are fully capable of handling. So we have two choices: (1) do not give any systems engineering metrics to our executives unless they ask for them (so they take the responsibility for knowing what to do with the data), or (2) develop some transformation of our systems engineering metrics into new metrics suitable for executives, and educate our executives about how to effectively use these new metrics.

The authors have not developed a candidate set of systems engineering metrics for executives. However, to give readers some more specific feeling for the characteristics of executive metrics which we believe could be useful, we have developed some possible executive systems engineering metrics. These are meant as illustrative only; they have not been proven through systematic use.

- *System-level requirements closure.* This could be a composite measure

of the degree of buy-in by all of the stakeholders plus the degree to which system requirements are completely defined and understood.

- *Functional allocation closure.* This could be a composite of the specific metrics used by the systems engineering team for lower-level requirements closure, plus the metrics for clarity of internal system, plus the metrics being used to understand the feasibility of the chosen design approaches for hardware and software. For this potential executive systems engineering metric, numbers of open issues and risks may be used, while at the lower (system engineering team) level the issues and risks themselves–rather than their number–may be the focus.

If such metrics are useful to the executives, they need to provide feedback to the folks who prepare the data, so the data providers do not lose interest. If the metrics are not useful to the executives, feedback might enable the systems engineers to provide other metrics that are more useful. Since resources are required to prepare metrics for executives, the feedback the executives provide on the usefulness of the metrics helps the organization to use its resources more effectively. If systems engineers are looking for an opportunity to persuade executives of the value of metrics, a problem that could have been prevented may offer such an opportunity. Metrics can provide timely information to an executive about how he or she can apply resources to mitigate risks before they become problems. A problem that dismays an executive can often provide the opportunity for discovery about the potential of metrics. Or, to put this in other words, the next time you, as a systems engineering manager or professional, are called on the carpet for some problem which executive management could have helped you prevent, look at it as an opportunity rather than punishment. Explain cogently to the executive how you can provide them information in the future which will help you jointly get insight into risks, so you can take action to avert further problems like the one which has occurred. The pain of a current problem will often provide the incentive for executives and organizations to be willing to consider change.

Conclusions on Executive Use of Systems Engineering Metrics

Effective systems engineering is often key to the success of projects, especially projects that are large and complex, or projects that are developing unprecedented systems. Insights into the progress and discoveries made by systems engineering can provide very useful information to the executives managing the enterprise, which can enable them to increase the chances for success of both the individual project and the enterprise as a whole. Systems engineering metrics, suitably transformed for executive use, and in combination with the information which tells executives how the metrics data can be used to better understand how the enterprise is performing, can be very powerful in improving project and long-term enterprise performance.

The most useful metrics for executives may be those which measure how much the organization knows and does not know, how well the organization is applying what it does know, and how effective planned tasks are at helping the organization discover those things that are critical to project success.

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An Apocryphal Metrics Case Study: A Composite of Real Experience on Programs

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Introduction and Case Background. The "Wellrun program" is apocryphal, to protect the names of programs and people whose experience is being shared and to provide a glimpse into actual systems engineering metrics use in industry. Several programs, including both large and small, government and commercial, and representing a spectrum of measurement practices, contributed to this composite experience. The process used to combine the experiences from these diverse programs into a single apocryphal case study was to choose the most salient aspects of metrics use from each program. The programs include those in which customers were very interested in metrics, a few in which key personnel (such as the program manager) were fully convinced of the business value of metrics, and some in which metrics were used primarily for internal program performance indications. In some cases, the apocryphal case study includes just one illustrative example of experience, which was seen in different forms on different programs. But for ease of insight into the use of metrics, and what we can learn from these experiences, a single background for the Wellrun program has been described to give the reader a basis for understanding.

Wellrun is a government program being managed using fast-track, commercial practices to deliver a better, faster and cheaper system. The program was won by the contractor through a competitive bidding process. The performing contractor chose to propose a very aggressive program schedule, as well as demanding technical goals, in order to offer more attractive value to the customer. The customer awarded the contract to the company perceived to offer the best value solution. The customer's assessment was that all of the bids had significant risks, but that the job was feasible. The contract form was cost plus award fee with a contract cap value only 20% above the base contract value. The customer and the contractor agreed that the Wellrun program would require careful, consistent management attention to be successful.

Metrics Intent

Since the Wellrun program schedule and technical plans were aggressive, the company decided to propose using metrics to provide visibility for the customer to give them confidence in progress and risk management. Metrics were presented at a management summary level at each monthly program status meeting with the customer, and all of the detailed metrics were made available to the entire program team, including the customer, on the program's internal website.

Proposed metrics included:

- Cost and schedule plan versus earned value
- Technical milestones planned versus completed
- Technical Performance Measures for key system parameters
- COTS planned versus actual functionality and quantities (hardware units and software equivalent lines of code)
- Action item and discrepancy report status (open, close and aging information)

Metrics were planned to be used by multiple organizational levels of the Wellrun program, including the leads on each of the engineering tasks on the program, the heads of each Integrated Product Team, and the managers of each of the major elements of the program.

Early Program Experience

- The Wellrun program proceeded through the early program phases, and well into design of the system. The experience on the program in each of the metrics areas is summarized below:
- "Cost and schedule plan versus earned value" were collected and used as planned. Both company and customer personnel had much past experience using these, and were comfortable with them.
- "Technical milestones planned versus completed" were collected, but did not yield as much insight into progress as anticipated. This was primarily due to exit criteria definitions that were not crisp, and became more fluid under pressure. In other words, when project team members were under pressure, they gave themselves credit for completion of tasks which would not have been judged to be fully complete had the exit criteria been rigorously defined and applied. Also, some items of this exit criteria were allowed to be moved into a later milestone's exit criteria.
- "Technical Performance Measures for key system parameters" were all defined in the proposal to the customer, but only a subset of planned TPMs got used early on. The remainder of the TPMs which had been listed in the proposal, did not seem important to project personnel as the job progressed, and so were not collected or used. In addition, several major risks were difficult to get insight into because there were no TPMs in those areas. The conclusion reached was that there needed to be stronger correlation between technical risks and the TPMs used on the project.
- Metrics on "COTS hardware planned versus actual functionality and quantities" were collected faithfully, but not much use was made of these metrics. Basically, this seemed to become a bean-

counting exercise, with not much added value.

- Metrics on "COTS software planned versus actual functionality and equivalent source lines of code" were collected as planned, although the criteria for giving COTS SW credit were not crisp. These metrics did prove to be useful for explaining the impact of COTS changes (one product did not meet needed functionality, one was dropped by its vendor). Again, these metrics would have been more useful if they had been more closely tied to program issues and risks, and were based on a good definition of what was considered COTS.
- Metrics on "action item and discrepancy report status" were not uniformly collected or tracked, but what metrics were collected in this area were of some use. Both company and customer program management focused attention on areas in which opening of new action items significantly exceeded action item closure, and areas in which action items stayed open overly long. This management attention helped clear up a number of issues, which might otherwise have seriously delayed the project.

Mid-Course Correction in Metrics Use

Roughly halfway through the program, the program management team decided to assess the metrics, and see if they were adding value. At this point in the program, the first (and major) iteration of the system design had been completed, and implementation had been started. Integration and test of several portions of the system which had been deemed to be high risk was mostly complete, although some of these implementations were prototypes on which additional design and implementation efforts were needed. So there was still design work to be completed, as well as implementation, integration and test. Enough implementation, integration and test work had been done to use all of the planned metrics to some extent, except for the few TPMs which had been in the original proposal to the customer and had never been used in practice.

There were several reasons for this re-examination of the metrics. Some program personnel had complained that metrics collection was a waste of time, and some customer personnel had expressed a concern that they were not getting as much insight into program progress and problems through metrics use as they had hoped. The program management team made a list of all of the metrics currently in use on the program, plus the additional metrics that had been in the proposal to the customer but were not in current use. For each of these metrics, they identified the person(s) and/or organization(s) who collected the metric, and the person(s) and/or organization(s) who were currently using the metric. People who collected the metrics were asked to give an approximate number of hours they spent each week on metrics collection. (Time counted as metrics collection time only if the activity they were doing would not have to be performed if the use of that metric were to be dropped.) All metrics that had no current users were either revised or dropped. In addition, metrics which were very labor-intensive to collect were reconsidered.

Some metrics were identified which should have been used, but were not. For instance, defect discovery and closure rates were being used by some team leads, but not by all. The intended users of these metrics were then given specific reporting requirements for their conclusions based on the metrics. This addressed the problem of some project leads and managers ignoring the metrics and just managing on gut feel. After this change, higher management was sure that the metrics were being reviewed by the managers and leads, and that action taken to address out-of-control values of metrics was explicitly identified to higher management and the customer. For most of the managers and leads, this meant a minor amount of additional reporting most of the time, but occasionally it alerted them to a problem or potential problem sooner than they might have otherwise noticed it, leading to reduced effort for rework and fix activities. For a very small minority of the leads and managers, this new requirement to report on their conclusions about the monthly metrics required significant changes in the way they spent their time and attention. Two of these leads/managers requested changes in job assignments back to individual contributor, so they could concentrate on what they saw as the "real work" and not what they considered "management nonsense." Several of the staff who had previously reported to these two leads/managers said their understanding of what they were supposed to do, and their insight into how their efforts fit into the overall program, improved significantly under their new lead/manager.

Risk management responsibility was clarified and appropriate metrics identified. Specific people and organizations' responsibilities for risk identification, risk assessment, and the development of possible mitigation approaches for risks were identified. A member of the program management team became responsible to review new risks, and recommend appropriate mitigation approaches, at least once a month (immediately if it was a serious risk). To ensure adequate priority was placed on risk identification, a concern was raised if no new risks were identified for two consecutive months. Risk metrics were identified to help: (a) identify when the risk became a real problem to be solved, or (b) when the probability of the risk changed significantly. If risk mitigation approaches did not produce any change in the metrics, the mitigation approach was re-examined for adequacy.

All technical and management organizations with formal responsibility for providing program checks and balances for the Wellrun program were given the responsibility to ensure that metrics collection and reporting was timely. Responses

varied by organization. Quality Assurance checked to see whether each metric for which they had oversight responsibility was in the database (newly set up as a result of this re-examination of the metrics program) by the designated date. Missing metrics were reported to the Program Manager, who focused on individuals and organizations who showed a pattern of failing to submit metrics in a timely fashion. Several of the functional organizations made very active efforts to help metrics users with interpretations of metrics, and developed templates to aid appropriate use of metrics in their functional area. In fact, over the longer term, some of the functional areas refined the planning templates and default procedures they provide to new projects to reflect some of this additional guidance about how to use metrics effectively.

More Program Experience

The program continued to completion after this re-examination and revision of the measurement process, and the revisions in the collection and use of specific metrics. The experience in each of the metrics areas on the remainder of the program is summarized below:

- "Cost and schedule plan versus earned value" continued to be collected and used as planned.
- "Technical milestones planned versus completed" metrics were used. Exit criteria definitions were made more explicit. The Quality Assurance organization was asked to check and confirm that the exit criteria were met before a technical milestone was counted as complete. In practice, about 3% of the technical milestones were found to be incomplete by Quality Assurance, most of which required a small amount of additional technical work to complete the milestone. In a few cases, the exit criteria were revised to be more realistic. "Inchstones planned versus completed" were measured in problem areas, and these metrics were used to focus management attention on areas where additional resources might need to be applied.
- "Technical Performance Measures for key system parameters" continued to be used, but a smaller set of TPMs than had been in the proposal was agreed upon. In addition, each time a new technical risk arose, program staff evaluated whether there was one (or more) TPM(s) which might be helpful in understanding the nature or severity of the risk over time, and some new TPMs were added to give insight into risks which arose.
- The metrics on "COTS hardware planned versus actual functionality and quantities" were dropped after receipt of most of the off-the-shelf hardware, since no one saw a further use for these metrics.
- The metrics for "COTS software planned versus actual functionality and equivalent source lines of code" were changed to function points. This proved to be especially helpful for understanding the impact of requirements changes (of which there were some, due to changing customer needs before the system development was complete).
- Metrics for "action item and discrepancy report status" were added to the problem tracking system used by the program. In addition, the program added action item tracking in this same system.

Summary and Conclusions

A number of summary observations and conclusions can be drawn from the apocryphal example of the Wellrun program:

- The participation of many stakeholders is required to make metrics as useful as they are capable of being.
- Examining the effectiveness of metrics, and revising or fine-tuning at intervals though the project improves metrics usefulness tremendously. Retire metrics that no longer address an active program issue.
- On an "easy" project, gut feel or simple tracking can be almost as effective as using metrics, is quicker, and is much more popular. However, we can't always tell in advance which projects will be easy.
- Metrics can be very effective in convincing outside stakeholders (for instance, customers, other disciplines, SETA contractors) that there is good visibility into progress. The progress visibility can improve the willingness of the outside stakeholders to enter into joint commitments and interdependent activities.
- Higher levels of management should limit the amount of detailed metric data required from the lower levels of management. Use of summary data and the conclusions from the lower level of management breeds responsibility and accountability, which are two program success factors.
- Changing metrics from time to time is probably necessary, just because people become numb to repeated news, especially when it is slightly bad. The change from one phase to the next in the program development life cycle provides a constructive opportunity for changes in metrics collection and use.
- Effective metrics are used as the reason for doing what is right, and needs to be done. Good people will usually do what is right, but it certainly doesn't hurt to give them some additional basis for doing what is needed.

Finally, it is worth noting that effective feedback loops are key to success on hard programs, whether implemented with quantitative metrics, or qualitative insights. If your program can use metrics to implement effective feedback loops, then metrics can be very helpful to program success.

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Getting Acquainted with the Measurement Information Systems Tool (MIST)

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Background. Suppose, as a system developer, you were asked the following questions:

- "What are the most appropriate measurements to collect on your development effort to ensure that the project is on time and within cost?"
- "If my project is in the early phases of its development lifecycle and both cost and reliability are important issues, what are the appropriate measurements to collect and how should they be employed to address these issues?"
- "Our business is producing software and I am concerned with my development process. What measurements should I be collecting on my process to assess it, and are there any tools available to assist me?"

These questions and more may be addressed by using a tool called the Measurement Information Systems Tool (MIST), that was jointly developed by the Naval Surface Warfare Center Dahlgren Division (NSWCDD) and the INCOSE Measurement Working Group (MWG). This cooperative development effort began in 1995. At the time, Dr. Farr was the lead of the measurement task for the Engineering of Complex Systems project sponsored by the Office of Naval Research (ONR). The task required identifying the key measurements to use in the evaluation; developing a validation methodology to ensure the measurements are appropriate within that process; and developing a measurement integration methodology that provides both component level and system level assessments. To store these key measurements, MIST was designed using a database developed by CACI International, Inc.[1]

[1] *CACI has been involved in MIST's development since its inception and is listed as one of the three (NSWCDD and INCOSE being the other two) principal developers of MIST.*

At an ONR forum in 1995, during an exchange of ideas on the measurement problems associated with large scale systems development, Dr. Donna Rhodes (the MWG chair at the time) invited Dr. Farr to speak to the MWG at the 1996 INCOSE International Workshop on some common strategic goals. The MWG strategic goals included industry association collaboration, a metrics repository, metrics automation, and metrics publications. To help meet these goals, the MWG had been working on the Metrics-In-Use Catalog that contained candidate metrics for process, progress, and product measurements. It was intended to promote a shared understanding of systems metrics and measurement practices, and to advance the state-of-the-art of measurement collection and utilization. The MWG had developed a template for defining a measure, that template was very similar to the taxonomy that Dr. Farr had developed for the measurement database. Because both groups were seeking the same objectives, it was decided to pool their efforts along with CACI in the development of MIST. The Navy group and CACI would continue the development of the database tool with some modifications and additions to accommodate the INCOSE framework, while the INCOSE MWG would help populate the database, and review and critique it. The final product would be distributed both as a Navy tool and as an INCOSE MWG product. The Navy would benefit from this joint effort by having access to measurement experts from all types of systems who would identify key measurements covering all phases of development. INCOSE would benefit by having a product developed that would encompass their measurement catalogue and provide a tool for dissemination of measurements at no cost.

Since 1996, when the initial agreement was established between these two organizations, the database tool has undergone some development iterations to arrive at its current capability and configuration. Additionally, enhancements have been made to the types of measurement attributes defined in the database based upon INCOSE MWG and Navy feedback. The final version (MIST '98 Version 1.0) will be released in December of 1998. It will be available on both the INCOSE MWG and the Naval Surface Warfare Center Dahlgren Division's web sites for downloading.

About The Tool

There is a need to identify key measures, both at the component and system levels, over all phases of the life cycle of a system's development. To adequately assess a system in the dimensions of performance, reliability, cost, security, etc., the key measurements must be defined and properly employed. MIST was developed to capture these measures and to provide a medium for exchange among different organizations. It is hoped that as the measures are exchanged, the MIST database will be both a dynamic and important resource in the measurement area. Although the information contained in the database has been selected with emphasis towards real-time systems, it should be of value to all system level managers and technical personnel who seek guidance in the effective implementation of a measurement program.

MIST is a Windows-based PC tool that was developed in a prototype environment using Microsoft's Visual FoxPro 5.0. MIST provides a taxonomy to classify the measures in its database. This taxonomy has several dimensions. Measures are characterized as to application type (process, project, product), category (hard-

ware, humanware, software, system level), phase of the life cycle (design, implementation, maintenance, requirements, testing), and system factor (cost, dependability, performance, security). In addition, the taxonomy relates to the SEI's Capability Maturity Model (CMM) for software development and the analogous INCOSE SE CMM for systems. This latter feature will allow users to determine which measures are appropriate to collect and analyze in order to move from the current maturity level to the next higher level.

MIST provides fourteen fields of information for each measure. The fields of information are: interpretation (description of results/benefits), implementation, lessons learned, available tools, measure formula, description of formula notation, required data, collection information (includes collection interval, measure type, and collection method), sample calculation, applicable life cycle factors, applicable measure factors, measure application type and subcategories, SEI Capability Maturity Model focus area and level, and detailed reference information.

MIST has several desirable features that enhance its flexibility as a tool for measurement program implementation. MIST contains a core database of measures. Users have the flexibility to tailor MIST to conform to their own program-specific requirements. Measures can be added to or deleted from the database. In addition, a measure can be modified if, for example, the user desires to include additional information in one or more of that measure's information fields. The major utility in MIST is that of searching the database for a specific measure or a group of similar measures of interest. Finally, MIST provides both file import and export capability. This feature permits the user to tailor the database to accommodate the specific needs of a particular measurement program.

USING MIST

The top-level menu has the following functions and associated sub-menu options:

FILE – you can **Import**, Export measurements, or **Exit** the program;

EDIT – you can perform many of the common editing functions such as **Find, Replace, Copy, Paste**, etc. to allow one to quickly add/modify textual material for a given measure

MEASUREMENTS – you can **Search** for a measure, **Add** or **Modify** a measure, and **Delete** a measure from the database

HELP – provides on-line help about the database and its use.

Under the **Search** sub-menu, one has the option of doing any of six different search types. Searches can be performed by author name, measure name, measure factor, life cycle factor, or measure application. A search by author name produces a listing of all measures attributable to the author or organization specified. If the user wishes to search for one specific measure, the measure name search option can be employed.

Measure factor is one component of the measurement taxonomy that breaks a measure down as to its applicability to performance, dependability, cost, and security. The life cycle factor relates to requirements, design, implementation, testing, and maintenance. For measurement application the user can specify whether it is a **Product, Process,** or **Project** type measure and further select if it is applicable to a **Hardware, Software, Humanware**, or **System** level measure. In all of these searches more than one selection may be picked. The user may also select whether a logical "And" or "Or" selection criteria is to be employed. For example, if the user selects for the search under Life Cycle factor both "Maintenance" and "Testing," the option of a logical "And" will generate a listing of all measures that are applicable for *both* maintenance and testing. If the "Or" was selected then all measures that can be applied to *either* maintenance and/or testing will be selected.

Additionally, the user can customize a search by utilizing an option called "**Build Search.**" This option permits the user to further tailor the search by specifying life cycle factor, measure factor, and measure application type (including subcategories) in any combination desired. Again the logical "And" and "Or" are available within each category. This is one of the most useful search options available in MIST.

For the selected measures found in the search, information is provided on various levels of detail. For the program manager, high level information is provided such as implementation considerations, interpretation, measure definition. For the technical practitioner, more detailed information is provided such as key references, measure formula, sample calculations, etc. All of the information can be printed in an attractive notebook format.

One of the powerful features of MIST is the capability to import or export measures from the database. This allows various users of MIST to share their measures. One can selectively choose the measure(s) to export (import) from the list of measures shown in the export (import) window or select all of the measures for export (import). If conflicts exist of similar names already residing in the host database from the import file, the user will be alerted. The user can skip the measure with the same name as the measure in the host database, thus by-passing it; rename it with another name and then add it to the host database; or overwrite the existing measure with the imported one.

A MIST'y Future?

For the immediate future, the MWG will take version 1.0 and review all of the measurements (currently 49) in the database to ensure correctness and completeness. If additional measures are needed they will be added. The final version will be ready at the end of December 1998. At the 1999 INCOSE International Workshop, the new tool will be demonstrated for the first time and

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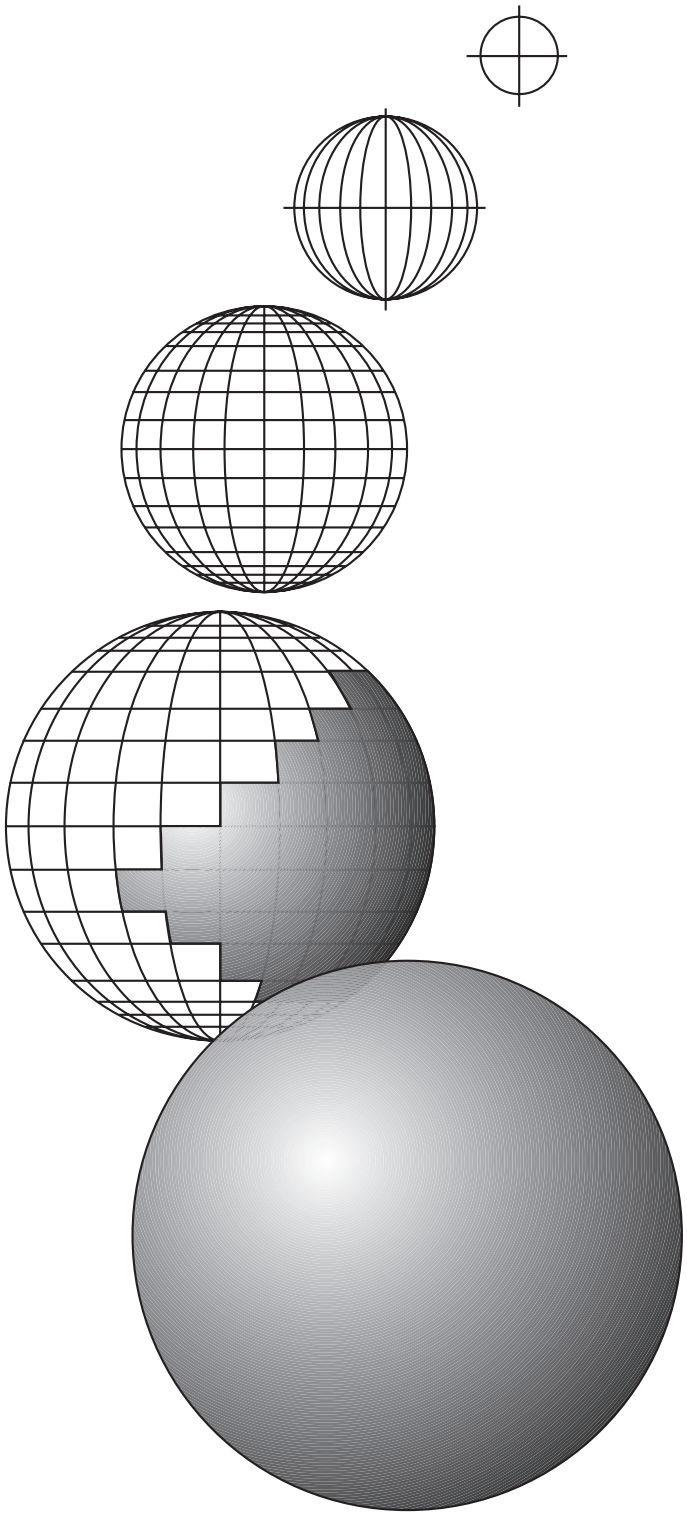

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Framework for Assessing Measurement Process Effectiveness

Peter Baxter, pbaxter@distributive.com

Introduction. Continued tuning of a measurement process to the needs of the organization is required for successful measurement implementation. Yet few organizations assess the effectiveness of the measurement process on a periodic basis, or implement an effectiveness assessment within the process itself. Measurement effectiveness is quantified by examining the extent to which the measurement process goals and objectives are met, and the extent to which managers utilize measurement information during decision-making.

The basis for the measurement process as practiced today is the Quality Circle, or Plan-Do-Study-Act (PDSA) approach, developed by Dr. Walter Shewhart in the early 1900s. The PDSA framework is shown, along with corresponding measurement activities, in the following diagram. The effectiveness assessment framework follows this quality circle, in concept, to provide an independent assessment of how well the entire process is being performed.

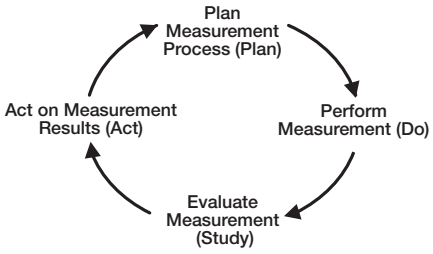

Figure 1

The Quality Circle iterates through all phases. The first iteration represents the initial measurement process definition, and subsequent iterations represent continued improvement to the process.

The "Plan" step involves determining the goals of the measurement process, and a translation of those goals into metrics. The "Do" step entails implementing the measurement process within the organization and the use of metrics to support decision making. The "Study" step involves the review and analysis of the measurement process activities and metrics data to understand how well the measurement process is working. The "Act" step provides a mechanism to take action on the observations and conclusions reached during the "Study" step.

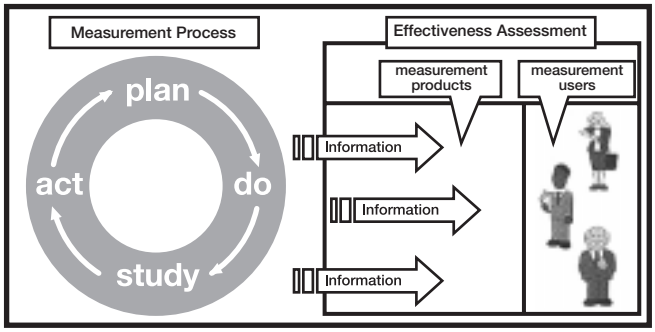

Figure 2

Measurement is one of several program management tools used to plan, control, and monitor technical activities. The measurement process provides an independent mechanism for quantifying the activities performed in the other essential project functions. It provides a picture of essential project status data from inception through to delivery or completion, which can be used to identify trends and the need for midcourse corrections.

For example, a measurement process may collect earned value data from the cost accounting system, development metrics from the subcontractors, and technical performance measures (TPMs) from the engineering activities and products.

Effectiveness Assessment in the Measurement Process

An effectiveness assessment quantifies the extent to which a process produces intended results. For measurement, the effectiveness assessment must quantify how well the measurement process provides timely, accurate, and useful information to decision makers. The relationship of the effectiveness assessment to the overall measurement process is shown in the following diagram (Figure 2).

The assessment framework involves soliciting measurement user feedback to quantify the benefit or utility received, determine whether or not the measurement process is focused on the organizational goals and issues, and identify areas where improvements or changes in provided information are needed. The effectiveness of the information provided is improved if the results of the "Plan" step are measurement process goals that reflect the needs of its users.

Effectiveness Assessment Goals

The effectiveness assessment relies on a set of clearly defined goals in order to focus the assessment activities and quantify the appropriate measurement process elements. The following provides a basic set of goals of the effectiveness assessment:

[G1]* Identify levels of management supported by the measurement process.
[G2] Quantify reliance on measurement process data during decision making.
[G3] Determine the extent that metrics address defined goals and objectives.
[G4] Quantify changes to measurement process information to accommodate organizational changes.

(* [G1] – [G4] are used later as identifiers that refer to these goals.)

Expectations of the Effectiveness Assessment

To aid the characterization of the measurement process, it is helpful to capture expectations, information needs, "lessons learned," and "Best Practices" in a common repository. This repository should address attributes of the measurement process, such as the following:

- information required by measurement users
- adequacy of defined measurement goals
- prioritization of measurement collection that is consistent with information needs and business goals
- unsupported information needs and actions to address them (or rationale not to)
- changes to the measurement process to address changes in goals, issues, engineering process, etc.
- effect of changes to the measurement process on the measurement effectiveness

Implementing Effectiveness Assessment

The effectiveness assessment itself contains a simple process that ensures repeatability and traceability of the assessment activities. This effectiveness assessment process, including the effectiveness assessment goals and assessment checklist, should be documented. Each time the process is performed, the results must be recorded in an effectiveness assessment report.

The organization should allocate adequate resources not only to plan and conduct the assessment, but also to implement the results received from the assessment. Such results would typically include measurement process recommendations for consideration during the next "Plan" step. While resource constraints are unavoidable, recommendations from the assessment should be implemented to the extent that resources allow.

As organizations become more mature, the effectiveness assessment may be performed at larger intervals as the causes of ineffective measurement are determined and root causes addressed. However, while the frequency of the assessments may decrease, the scope of the assessment may increase, as more information is provided and more users and organizational levels of management are supported.

Effectiveness Assessment Process

Activities performed during an effectiveness assessment should use a formal, documented assessment process. An assessment process description should be generated and include the development of assessment checklist questions. For each assessment checklist item, relevant measurement, or a process policy or standard, should be referenced to simplify the assessment tasks.

All effectiveness assessment checklist items are intended to be mandatory (and applicable). For applicable items, the assessors must determine how many of the assessment points to assign based on the objective criteria established for each question. In addition, the location of any relevant information, as well as assessment notes, should be recorded. Should items be found to be not applicable, the associated assessment points are noted as being not assigned.

Effectiveness Assessment Repeatability

The assessment framework contains elements that ensure that two or more assessments on the same measurement process under the same conditions produce identical results in order to provide confidence in the results. Consistency of results can be achieved by ensuring:

- *Assessors understand* (1) the measurement process being assessed, (2) the relationship of the measurement process to other management and engineering standards, (3) how data is collected and analyzed, and (4) how and when measurement information is delivered to managers.
- *The effectiveness assessment process is clearly defined, documented, and approved,* including a set of assessment goals and, for each goal, a weight and set of questions (contained in a "checklist") to quantify how well the goal is met.
- *All checklist questions are mandatory and must be answered during the assessment.*
- *Checklist questions are stated in objective language.* Each checklist question should contain a binary ordinal (0 or 1) or range of numerical values (i.e. 1–3) and a description of how to select a value from within the allowable range.

Effectiveness Assessment Checklist

The following list (Table 1) contains sample checklist items that are grouped according to which effectiveness assessment goal they support. Each item to be assessed is stated as a yes or no question in the following table. For simplicity, a "no" (or not applicable) item receives zero (0) points and a "yes" answer receives one (1) point.

The checklist can be used to quickly identify opportunity areas in existing measurement processes, or to aid in the creation of a new measurement process. It could also be used as the basis for constructing an assessment framework tailored to a specific organizational measurement process. For the assessment interpretation, a higher score indicates a more effective implementation.

Effectiveness Assessment Report

The results of the assessment should be documented in a report. This assessment report should contain the following information:

- Goals of the effectiveness assessment
- Assessment team members
- Date and duration of the assessment
- Measurement process standard or policy in use

Table 1. Effectiveness Assessment Checklist

Identify levels of management supported by the measurement process [G1]	
G1.a	Has the organizational structure been accurately defined?
G1.b	Have the information needs at all organizational levels been described?
G1.c	Have the issues to be addressed been defined?
G1.d	Are measurement process goals clearly defined?
G1.e	Are measurement goals periodically updated?
Quantify reliance on measurement process data during decision making [G2]	
G2.a	Were measurement goals used as the basis for metric selection?
G2.b	Did the metric selection process follow a defined metric selection technique?
G2.c	Were the candidate metrics prioritized?
G2.d	Do the metrics pass the litmus test?
G2.e	Does the measurement process implementation support all levels of management?
G2.f	Did the organization approve the scope of the measurement process?
G2.g	Were adequate resources allocated to the measurement process?
G2.h	Were the resources estimates based on credible data?
G2.i	Is there a measurement process plan?
G2.j	Do engineering process definitions support/reference measurement process?
Determine the extent that metrics address defined goals and objectives [G3]	
G3.a	Are managers using measurement data during decision-making?
G3.b	Are all metrics collected at the frequency specified?
G3.c	Is the associated metric data accurate and valid?
G3.d	Is measurement data timely?
G3.e	Are adequate SPC techniques employed?
G3.f	Are managers receiving periodic reports?
G3.g	Is there a central organizational repository for measurement data?
G3.h	Is the repository used in implementing new or improving existing measurement processes?
Quantify changes to measurement process information to accommodate organizational changes [G4]	
G4.a	Does the organization have a mechanism for assessing the measurement process?
G4.b	Does a team consisting substantially of managers and other measurement stakeholders conduct the assessment?
G4.c	Is the assessment performed on a periodic basis?
G4.d	Are corrective actions resulting from the assessment implemented?
G4.e	Is the definition, context and historical performance of successful metrics present in the repository?
G4.f	Is the definition, context and historical performance of unsuccessful metrics present in the repository?

- For each checklist item,
  1) supporting information (when present)
  2) assessment results
  3) points allocated
- Scoring summary
- Recommendations for improvement

The report can be tailored to the organization, as needed.

Future Directions

Distributive Data Systems developed this measurement assessment framework through its experience in measurement process implementation. It will be submitted to the INCOSE Measurement Working Group (MWG) for consideration as a future project. The author expects that this framework will be accepted as part of an INCOSE MWG project in the next year. The objectives of this project may be to refine this process and to look at its relationship to the existing/emerging standards, models, and leading practices. Lessons learned will be documented and more detailed guidelines, criteria, and verification procedures will be developed and published.

Peter Baxter *(pbaxter@distributive.com) is the Development Manager of measurement and process improvement software tools at Distributive Data Systems (DDS).*

MIST *continued from page 19*

made available to INCOSE members who would like a copy. Over the next year, any necessary corrections in Version 1.0 will be made, as well as prioritized recommendations and enhancements. Additionally, the database will be more extensively populated as certain key areas (e.g. security and human factors) are lacking in key measures.

Future enhancements include making the tool compatible with Practical Software Measurement's (PSM) tool called Insight, and incorporating the measures found in the *PSM Guidebook* (Version 3.1a) and the measures from the Practical Systems Measurement guidance currently under development by the PSM initiative and the INCOSE MWG.

REFERENCES

Practical Software Measurement: A Foundation for Objective Project Management, Version 3.1a, 1996

Rhodes, Donna., Roedler, Garry., et. al., *Systems Engineering Measurement Primer,* Version 1.0, INCOSE, March 1998.

Dr. William Farr *is a Branch Chief for the Systems Research & Technology Department of the Naval Surface Warfare Center Dahlgren Division. He is the co-lead of the Practical Systems Measurement project and is an active member of the INCOSE MWG.*

Working Groups

Educational Measurement Working Group Gets Underway

Peter Sydenham, Chair, Sydenham@senet.com.au

Following two previous attempts, a Working Group for Educational Measurement was created at INCOSE's 1998 symposium. Contributions prior to July 1998 had considered formal accreditation and syllabus generation issues, but little agreement was achieved. Accreditation was considered to be highly contentious.

Then, around 1997 Brian Mar provided the appropriate part of the INCOSE Technical Operating Plan.

'ACTIVITY 6.7— CURRICULA DEVELOPMENT AND CERTIFICATION.

Facilitate and participate in the development of systems engineering related curricula.

Establish criteria for INCOSE accreditation of systems engineering degrees.'

Leading up to the Vancouver Symposium, I was not previously involved with this activity, and being experienced in global university processes, I decided to join the debate suggesting work toward a Board of Accreditation.

Phil Brown chaired the Education and Research Technical Committee meeting held during the symposium. Some 20 people were present to hear my presentation on accreditation. Debate soon established that accreditation was certainly not the way forward due to its unacceptable mandatory terms. Brian Mar suggested a better path might be to pursue self-assessment based on a form of educational maturity model. This found favor and he then assisted in developing a "Charter of the Educational Measurements Working Group."

Another important event held during the symposium was the Academic Forum, chaired by Stanley Weiss. Around 50 persons attended, giving a good representation of industrial and academic viewpoints. As a part of the day's activities, I gave a revised presentation that reflected the new approach. Key points were:

Task in Hand

- How to advance INCOSE Activity 6.7 "Curricula Development and Certification"

Charter Outline

- Assist employers to evaluate the knowledge and qualifications of graduates in SE
- Allow educational units to self-assess and improve offerings
- Allow potential students to evaluate and select offerings

Objectives

- Create a forum to develop requirements of metrics and processes
- Develop the metrics and processes
- Institutionalize metrics and processes, and continually improve them
- Work with other groups who already license and accredit, and share results

Products and Schedule

- Terms, framework and classification—October 1998
- Survey membership and providers on their metrics and processes—January 1999
- V1.0 candidate evaluation models, to test—January 1999
- V1.0 released for self assessment — June 1999
- Assess and collect data—September 1999
- Annual return and progress report—each January

Debate was spirited and generally positive. Specific comments were:

- Third party evaluation - this discussed external evaluation of university programs as a general principle. This issue led to the next.
- Alleged intolerance of accreditation efforts by U.S. research universities - the case was made by one person that *all major U.S. research universities* were united in their resistance to external accreditation and that attempts to implement this would damage relations between INCOSE and that group of universities. A strong recommendation was made that the new Working Group investigate this possibility. The importance of taking notice of prior considerations by INCOSE was stressed.
- Possible expansion to other fields — at least two participants noted that a well-grounded evaluation tool for educational offerings could be generalized to other fields and thus be consistent with current changes in the U.S.-based Accreditation Board for Engineering and Technology (ABET) criteria.

The debate highlighted that INCOSE, being international, needed to explore not only its past debates on this issue but also how the non-U.S. universities operate. In many other countries accreditation/recognition is an essential activity. Anyone with notes of meetings, or who can submit reports on prior debate, is invited to assist the WG.

Overall, the majority of attendees supported the proposal for self-assessment using metrics. Education and Research Technical Committee Chairman, Dennis Buede, subsequently recommended an Educational Measurements Working Group (EMWG) to the Technical Board.

Setting up the EMWG. An international team is now needed to meet the schedule. Membership types are:

- *Working Member* (WM). Participates in meetings and assists development of products. Meetings will be mainly twice

per year, at the main INCOSE events. It is unlikely that other face to face meetings will be held.
- *Reviewing Member* (RM). Participates regularly in reviews of products. Attends some meetings. Contributes as and where appropriate.
- *Information Member* (IM). Reviews and participates by email as and when able to do so.
- *Copy Member* (CM). Receives key information of EMWG activities and decisions so as to be kept up to date. Contributes as and where appropriate.

At the time of writing (September 1998) the many people who expressed interest are being confirmed as to their role. In addition, a leaflet will soon be released about the EMWG and it is an intention to have an EMWG Web site home page. Progress will be reported and debated at the INCOSE International Workshop to be held 25-28 January 1999. Any persons interested in participating in the work of the EMWG should email Peter Sydenham.

Promote INCOSE!

To obtain materials to promote INCOSE in the workplace and at events such as regional conferences, symposia, and National Engineer's Week, contact the INCOSE Central Office at –

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Systems Engineering Applications Technical Committee Activities

William Mackey, wmackey@csc.com

The Systems Engineering Applications Technical Committee (SEATC) is chartered to "foster the formation and operation of working groups (WGs) and interest groups (IGs) within specific application domains and across domains; and examine systems engineering tools, techniques, and processes within specific application domains." It is the only INCOSE Technical Committee solely focused on systems engineering applications in government, academia, industry and other non-profit organizations.

The SEATC met at the 1998 symposium to review the work of the SEATC and to prepare for the 1999 International Symposium in Brighton, England. We were pleased that a few people accomplished a great deal of work during the week. This article summarizes the recent activities of the SEATC and indicates the direction that the SEATC members supported in Vancouver.

We decided to continue the excellent work of the following WGs/IGs:

- Commercial and Public Interest WG (CPIWG) led by Mark Austin (austin@isr.umd.edu, 301-405-6627) and William Mackey (wmackey@csc.com, 301-794-2138)
- Facilities Systems Engineering WG (FSEWG) led by Pat Sweeney (sweeney@hap.arnold.af.mil, 615-454-4709) and Bill Henderson (hendersonwf@hap.arnold.af.mil, 615-454-5295)
- Telecommunications WG (TELWG) led by Tom Bagg (tom.bagg@gsfc.nasa.gov, 301-809-2216)
- Commercial Aviation IG (CAIG) led by Joe Simpson (joseph.j.simpson@boeing.com, 206-781-7089) and Scott Jackson (scott.jackson@boeing.com, 562-496-5049)
- DOE SE Practices IG (DOEIG) led by Sam Rindskopf (m.sam_rindskopf@notes.ymp.gov, 702-295-3965) and Norm Cole (ncole@inel.gov, 208-526-5004)
- Railway Transportation IG (RWTIG) led by our first international chairman from the United Kingdom, John Williams (jsw@netcomuk.co.uk, 011-44-181-392-9776) and Jeff Allan (jallan@ee-alta.bham.ac.uk)
- Resource Management IG (RMIG) led by Ted Dolton (alanjoanne@aol.com, 408-743-1358) and Bill Cutler (billcutler@compuserve.com, 650-493-8715)

Two new IGs are in the process of being formed as a result of increased interest in these application domains, namely:

- Motor Vehicles IG (MVIG) led by Paul Berry (pberry@ford.com, 313-323-0906)
- Health Care IG (HCIG), leader to be named

If you believe you have experience or significant interest in one of these groups, please let the chairpersons know at your earliest convenience.

The SEATC has specific goals for each year, and its members work very hard to accomplish them. As of October 1998, here is how we are doing with regard to the 1998-99 goals that we created in Vancouver, BC during July 1998.

Goal 1: Improve and modify the Systems Engineering Applications Profiles (SEAP) document for the Summer Symposium in 1999 and place it on the Web.

Status: The SEAP Version 2.0 was completed on July 1, 1998 and released at the 1998 Symposium in Vancouver, BC. The SEAP Version 2.0 is now on the INCOSE under the SEATC Products. Also check the University of Maryland

Website that has been built as a prototype for the INCOSE SEAP by Professor Mark Austin who is now leading the Commercial and Public Interest WG. Go to EE623 under the following URL: http://www.isr.umd.edu/~austin

Goal 2: Initiate new SEATC work products in all WG/IGs.
Status: The following products have been completed by the WG/IGs:

- Systems Engineering Applications Profiles (SEAP), July 1, 1998 (Version 2.0 was released at the 1998 Symposium in Vancouver, and is presently on the INCOSE Webpage under SEATC Products).
- A Multilevel Participation Plan was completed in 1998 by Scott Jackson and included as Appendix G of the SEAP Version 2.0.
- An Application Domain Template was also developed in 1998 by Scott Jackson and approved by the SEATC for trial use by the CAIG to create a Commercial Aviation Guideline Document.

We have done a lot of good work, but we are not stopping, so please plan to help us with items like:

- New SE applications profiles
- Summaries of SE applications papers
- Case studies of SE applications
- List of SE activities and events of other related societies

Goal 3: Conduct Systems Engineering Applications Sessions at the 9th Annual International Symposium in Brighton, England on June 6-10, 1999 on diverse systems engineering applications.
Status: The SEATC Chair has maintained contact with Allen Fairbairn, Symposium Technical Chair, since the Vancouver Symposium; SE Applications Domain specific paper sessions are planned for the Brighton Symposium.

Goal 4: Conduct one or more SE Panel Sessions at the Brighton Symposium.
Status: The SEATC has proposed three panel sessions for consideration at the Brighton, England International Symposium in 1999. They are:

a) "Issues Related to the Deployment of Systems Engineering in the Commercial and Public Interest Applications"
b) "Using Internet for Expanding the Services of Systems Engineering"
c) "Systems Engineering Aspects of Environmental Restoration and Waste Management"

Goal 5: Continue contact with universities which offer a Systems Engineering curriculum to gain their participation in the SEATC.
Status: Contacts are underway across the nation with systems engineering students and faculty at universities such as Virginia Tech, George Mason University, the University of Maryland, and the University of Arizona. Several SEATC members are involved in these activities.

Goal 6: Obtain a complete complement of INCOSE Interest Groups in local chapters.
Status: Five chapters have accepted the challenge and are conducting or proposing programs in their local chapters. The San Francisco Bay Area Chapter has had as many as eight volunteer projects underway in Natural Resource Management. On October 27-28, 1998, the Nevada Silver State Chapter is conducting a Workshop entitled "Systems Engineering Within the DOE Complex." Also, members of the Washington Metro Chapter are writing a DOE Guide. Congratulations to these chapters!

Goal 7: Improve Team Building and Communications in the all SEATC WG/IGs
Status: It is apparent that lack of resources, limited commitment in a volunteer organization and downsizing in many industries have caused a few people to carry the burden in virtually all INCOSE committees. The SEATC is fortunate in that the people who comprise it have demonstrated for several years that they are willingly to work well together and to produce materials useful to the SEATC and to INCOSE. Nevertheless, we in the SEATC believe we can to better in encouraging active participation in all WG/IG activities.

If you like exciting activity and are interested in SE applications, please join one of our WGs/IGs. Anyone interested in rolling up the sleeves and supporting the goals and interests of the SEATC please contact William Mackey at wmackey@csc.com, 301-794-2138 or Scott Jackson at scott.jackson@ boeing.com, 562-496-5049.

I wish to thank all of the SEATC members who contributed to the realization of all our goals for 1998 and those who stimulated us in Vancouver to continue the good work in 1998. I hope to see many of you in Phoenix in January and Brighton, England next summer.

Measurement Working Group Makes Each Day Count

Garry Roedler, Chair, garry.j.roedler@lmco.com

The INCOSE Measurement Working Group (MWG) has continued to gain new members and focus on what products are valuable to its members and their organizations. The recognized importance of the MWG's stated mission and value of its products has helped to maintain its momentum and productivity. The MWG mission is: *"Promote shared understanding and advancement of systems engineering measures, measurement practices, measurement tools and support, and the overall measurement process."*

Measurement is an underlying foundation element for process evaluation and improvement and effective project management. However, since measurement is a process itself, effective measurement requires careful planning. The measurement tasks must be planned to address project and organization issues and ensure that we measure the right things and we measure them right. The MWG works to help its members and INCOSE have the knowledge and tools to meet its mission.

The MWG has several strategic goals to guide its activities. The following summarizes these goals and how the MWG is addressing them:

1. **Unification of Measurement Guidance** — The MWG is working closely with other measurement initiatives to create a consistent set of guidance and support products. Where appropriate joint products are being developed.

2. **Industry Association and External Organization Collaboration** — The MWG continues to investigate potential collaborative projects with other industry associations and external organizations. Currently, collaborative projects have been established with:

   - **Practical Software Measurement** (PSM) initiative (sponsored by the Office of the Under Secretary of Defense, Acquisition and Technology) in the development of Practical Systems Measurement (PSysM) guidance. So far, this effort has yielded the SE Measurement Issues, Categories, and Measures List (see article entitled "Measurement, Standards, and Models" on page 6), as well as adapted guidance and preliminary definitions of some of the measures on the list. The first release of completed guidance is scheduled for mid-1999.
   - **Naval Surface Warfare Center Dahlgren Division** in the development of the Measurement Information Systems Tool (MIST). MIST is an online tool to aid in selecting appropriate measures (see article entitled "Getting Acquainted with the Measurement Information Systems Tool" on page 18). Its official first release will be at the January 1999 INCOSE International Workshop.

3. **Publication of Systems Measurement Related Topics** — The MWG released the *INCOSE Systems Engineering Measurement Primer* in March 1998. This was the second guidance document the MWG has produced in the past few years. The other was the *Metrics Guidebook for Integrated Systems and Product Development,* which was released in July 1995. The MWG has also been a consistent contributor to INCOSE ***INSIGHT*** with its articles on Measurement Frequently Asked Questions and MWG status in each issue for the past two years. For this issue of INCOSE ***INSIGHT***, the MWG is the theme sponsor. Additionally, the MWG has had some less visible products that have been available informally to INCOSE members, including an Annotated Bibliography and the Metrics-In-Use Catalog (which has since been rolled into MIST).

4. **Integrate Measurement into the INCOSE Product Line** — This goal requires better intergroup coordination across INCOSE. The MWG has made some significant strides towards achieving this goal. Two of the MWG members were active in the development and review of the *INCOSE Systems Engineering Handbook* that was released in January 1998. They ensured that systems engineering measurement was adequately addressed consistently with the MWG guidance. Recently, the MWG has had discussions with the Risk Management WG to determine whether a similar integrated product should be considered. Further discussion will be planned for the 1999 INCOSE International Workshop. Finally, the MWG has just completed a set of measurement tool requirements that will be provided to the Tools Database WG to establish a measurement tools information base.

5. **Promote Training and Tools for Systems Measurement** — The MWG measurement tools requirements and subsequent vendor survey by the Tools Database WG also addresses this goal. With respect to training, some of the MWG and Measurement Technical Committee members have put together a tutorial entitled "Putting a Yardstick to Systems Engineering" that was presented at the Washington Metropolitan Area Chapter in November 1997. Additionally, some of the MWG members are working with the PSM initiative to establish a systems version of the PSM training. Tentatively, a pilot version of this training may be provided at the 1999 INCOSE International Workshop and the final version at the 1999 INCOSE International Symposium.

6. **Promote Real-life, Proven, and Validated Experience** — To meet this goal, the MWG has been getting its members to brief the MWG at its meeting on Lessons Learned in systems measurement. Some of these lessons learned have been documented in the FAQ responses and in some of the articles in this issue of ***INSIGHT*** (see articles entitled "An Apocryphal Case Study: A Composite of Real Experience on Programs" and "Executive Use of Metrics: Observations and Ruminations.") The lessons learned and proven experience is also the basis of the guidance that has been published by the MWG through INCOSE and in its work with collaborative projects.
7. **Promote Research into New Concepts, Applications, and Tools**— This goal requires developing an understanding of current and future measurement practitioner needs. Since the MWG is composed of measurement practitioners from a wide cross section of industry, government, and academia, there is a wealth ideas and insight into these needs. Each year, at the INCOSE International Workshop, the MWG dedicates part of its agenda to identifying and prioritizing the new measurement needs and associated candidate projects and products. This is how the MWG got involved in the development of MIST. Several new ideas and projects will be presented for consideration this year. The MWG's collaborative projects have been a significant part of meeting this goal.

By design, these goals map to many of the INCOSE strategic goals. The MWG will continue to include the applicable goals of the INCOSE organization in its planning and strive to meet the goals. This has been an effective year for the MWG; one in which we have seen sustained growth in the participation and interest of the working group, as well as increased reach of our ideas, guidance, and influence. We would like to take this opportunity to thank all of the participants of the MWG for their efforts and look forward to a productive 1999.

For more information regarding the INCOSE Measurement Working Group, contact: Garry Roedler (Chair, (610) 531-7845, garry.j.roedler@lmco.com; Don Gantzer (Co-chair, (202) 651-2288, Don.Gantzer@faa.dot.gov).

Measurement: Frequently Asked Questions

Ken Stranc, kjstranc@tasc.com

Question: How can measurement be implemented on projects in a way that minimizes the use of resources and effort while still producing valuable insight to support management decisions?

Response: The most straightforward answer to this question is that you should only measure that which is critical to the success of your project. This means that you must first identify your project's critical issues. Prioritize these issues to determine which are most important in achieving success. You then need to select measures having desirable attributes as described in Section 3.1.1.1 of the INCOSE *Systems Engineering Measurement Primer*. For example, ensure that each measurement is used for a reason (relevance), i.e., that it provides insight into a critical risk or issue. The insight afforded by the measurement should motivate you to take action when the measurement indicates a deviation from your plan. Also, be certain that you will have time to make the necessary changes (timeliness) in reaction to the measurement's message. It is always a good idea to select the simplest measure that fits the need (simplicity) to keep the effort associated with data collection, analysis, and reporting to a minimum. Even when you have selected measures with these desirable attributes, you still may not be able to afford them in light of their potential payback to your project (cost-effectiveness).

As you conduct your project and reach a process control point, the most beneficial step you can take is to take the time to reassess your measurement activities. This allows you to remove those measures that are no longer useful and to incorporate new measures that will provide you information to support management decisions throughout the current phase of the project. Continually tailor measurements to address specific needs, issues and challenges. Finally, require your staff to articulate their expectations for each measure over a period of time, and focus your attention on deviations from planned or expected values, not just the raw numbers. Immediately take action when deviations occur to bring the project, process, or product's performance back in line with expectations.

Question: What is a Technical Performance Measure?

Response: A Technical Performance Measure (TPM) is an attribute of a system that can be measured as the system is being developed in order to predict whether the system will satisfy or meet a technical requirement or goal. The future value of the TPM is predicted based upon a current assessment of lower-level products in the system structure through estimation, engineering analysis, and tests.

For example, consider system response time to a user request as a TPM. Looking at the thread through the system that the user's request must follow, each function that must be performed to satisfy the user's request is usually allocated a time budget. As the system is being built and more is learned, measured, estimated, and analyzed about the ability of each function to operate within its time budget, the sum of all the current time estimates for individual functions will show the theoretical end-to-end system response time. By taking this measure periodically as system development progresses, you will expect to see a trend from which you can extrapolate a value for this TPM at some future time.

A PICTURE IS WORTH A THOUSAND HOURS.

The path to a successful embedded system is often blocked by that age-old obstacle– the rush to implementation without adequate time to analyze design alternatives and verify your system's behavior. *Sound familiar?*

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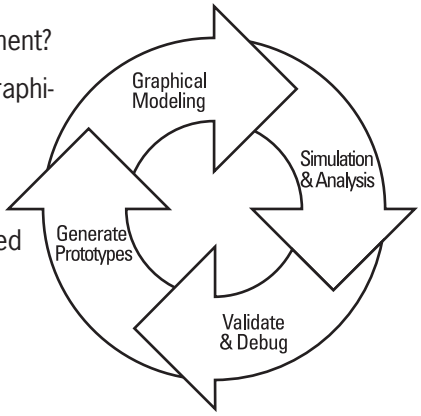

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News from Chapters

Colorado Chapter

Jerry Huller, Communications Director,
j.huller@ieee.org

The Colorado Chapter has elected new officers for 1998-1999:

President: Don Marquet, Lockheed Martin Astronautics, (donald.w.marquet@lmco.com)
President Elect/Vice President/ Acting Webmaster: D. Alex Chuang, TSG International
Past President/Acting Membership Chair: Jim Haney, Raytheon Systems Company
Treasurer: Ray Hoppes, Lockheed Martin Mission Systems
Communications Director: Jerry Huller, Raytheon Systems Co.
Technical Director: George Richie, ANSER Analytical Services Colorado Springs Area
Director: Matt Carroll, SAIC Colorado Springs Area
Director: Willie Walker, Jr., MCI
Denver Area Director: Dave Hottman, Compliance Automation
Denver Area Director: Lenny Mell, Pathfinder Solutions

Two meetings have been held so far. The September meeting featured a timely and informative talk by T. James LeDoux and Dr. Larry Smith on "Year 2000 Litigation, Legal Issues, Due Diligence, and Other Business Challenges." Members learned that there is a balance between documenting the reasonable actions you are taking (to show due diligence) and documenting too much, which can be used as ammunition against you and your company by the opposing lawyers. All documentation is subject to discovery (and mis-use) as part of the legal process. Engineers should keep records of communications with higher-ups about problems and issues. When reporting a problem or issue, include a recommendation to address it (again for the sake of due diligence). To avoid claims of negligence, make a reasonable effort, protect test results, and follow your company's standards and processes.

The October meeting included a presentation on "Applying Systems Thinking to Career Planning and Management," by Valerie Ness (Senior Career Advisor, Bernard Haldane Associates) and D. Alex Chuang (Chapter President-Elect). Career planning and management can be modeled as a requirements management process. An individual's "parameters" such as competencies and goals can be assessed via skill assessment worksheets. Targets and strategies can be assessed through career roadmap worksheets. Practical examples of these worksheets were presented. The benefits of career coaching and planning could be a 20-50% increase in the number of job offers for senior level people.

The November meeting presented "Software Disasters: How to Avoid Buying Them or Building Them," by J. Gordon Till, TCI Program Office, Chief Technical Development Architect.

Meetings are generally held on the third Tuesday of each month, and rotate between Colorado Springs/Castle Rock and Denver.

A tutorial for members and prospective members is planned for the spring of 1999. Last spring's tutorial on Systems Architecting by Dr. Mark Maier increased chapter membership by about 20%. The Chapter is also planning to host a Region II Mini-Conference for March 2000.

More information about the chapter and chapter events can be found at the Colorado Chapter's new website at http://www.incoseCO.org. The site also has pictures of the Vancouver Symposium.

Inland Empire

Petrus (Pete) J. Kaufman,
Petrus.Kaufman@trw.com

The Inland Empire Chapter (IEC), San Bernardino CA, in conjunction with the University of California Riverside (UCR), announce the following Systems Engineering (SE) course dates and times:

- ***Introduction to Systems Engineering Management.*** Riverside, CA. Beginning with the basis and need for such a methodology; the entire process including foundation concepts is explored. Tuesday, January 12, and Thursday, January 14, 6:30-9:30 pm; Saturday, January 23, 9 am-4 pm. Fee: $180.
- ***System Verification,*** Riverside, CA. Focuses on the establishment of conformance verification processes, including planning, design, development, and management. (Course prerequisite: EGR X463, Introduction to System Engineering.) January 28 –April 1, 1999. Fee: $240.

For additional information, contact UCR Extension at (909) 787-4111 or check out the Web site: www.unex.ucr.edu. Visit the Inland Empire Chapter Web site: www.IEC-incose.org

Norway Chapter Is Now Chartered!

Present in the picture (from left to Right) Rear: Tor Brendeford, Vebjørn Småberg, Hans Jørgen Dahl, Frode Getmer-Rønning, Nils Johan Jacobsen *Front:* Odd A. Asbjørnsen, Cecilia Haskins, Terje Fossnes

San Francisco Bay Area

Lew Lee, President, lew.lee@trw.com

Our chapter continues to serve its membership and the Silicon Valley with quality monthly presentations. Recently we have featured:

- September – *"Systems Engineering and Marketing, Making it Work in the Requirements Development Phase,"* by David Paul (Lockheed Martin Missiles & Space)
- October – *"The Systems/Software Engineering Interface: Impact of COTS and New Software Technology Developments,"* Dorothy McKinney (Lockheed Martin Missiles & Space)
- November – *"A Risk Reducing Approach to Evolving Improved Product Development Capabilities,"* Kenneth Kolence (Kolence Associates)
- December – *"Computing Without Zeroes – A History of Slide Rules and More,"* Robert Otnes

Dorothy McKinney's presentation in October was to a joint audience of INCOSE and the Silicon Valley Software Process Improvement Network (SV-SPIN). Dorothy presented a half-day, extended version of the topic to the Los Angeles SPIN, two months earlier. The local SPIN organization proposed we hold a combined meeting to reprise Dorothy's successful presentation.

We also inaugurated an audience response form at the October meeting. Jim Sloane (Design and Management Explorations) provided us with this valuable service by creating the form and compiling the responses from each month's meeting. We have received several suggestions for program topics and presenters.

Beginning in January, the chapter's monthly meetings will be moved to Lockheed Martin Missiles and Space in Sunnyvale. We have enjoyed the hospitality of GTE Government Systems in Mountain View for the past three years. GTE provided us with a superb meeting facility, excellent caterer, and a talented videography staff. Our thanks go to Dr. Dave Preklas (GTE Government Systems) and before him, Ron Olson (currently with Zeta) for having sponsored the chapter's use of the facility. We're looking forward to holding meetings at LMMS where a large portion of our membership is employed.

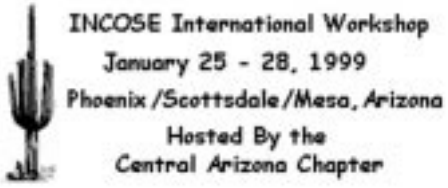
As announced in the previous issue of ***INSIGHT***, the SF Bay Area Chapter introduced another first in bringing added value to an INCOSE membership. In November 1998, Mr. Barney Morais and Dr. Brian Mar inaugurated our "core series" of tutorials with "Fundamentals of Engineering Complex Systems" to an attentive audience of 43.

Beginning in January 1999, we will offer tutorials on a monthly basis (nominally the 4th Saturday of the month). We plan a hiatus for the summer months and the schedule resumes in September. Chapter board members, Bob Barter and Aleta Vinzant (both of Lawrence Livermore National Laboratory) have taken the lead in organizing these events. In advance of their support, we sincerely thank the presenters for their support in bringing high quality, excellent value tutorials to the San Francisco Bay Area. If you are within commuting distance, consider attending our tutorials. If you're outside of the area, please visit our Web site (see below), examine the schedule, and observe our progress. Upcoming monthly meetings include:

- January 12 - SFBAC monthly meeting featuring Mr. Chris Hoeber, Space Systems Loral. Program title to be announced.
- February 9 - SFBAC monthly meeting. Program to be announced.
- March 9 - SFBAC monthly meeting. Program to be announced.
- April 13 - SFBAC monthly meeting. Program to be announced.

All meetings are held at Lockheed Martin Missiles & Space in Sunnyvale at 5:30 p.m. For announcements and directions, check our Web site: http://www.relay.net/~lew/sfbac.html.

In December, we hold elections for chapter officers and directors. We have an excellent slate of candidates who have the energy and drive to maintain our chapter's leadership position in INCOSE.



Joseph Juarez, Chair 1999 International Workshop Committee, Joseph.Juarez@CAS.honeywell.com.

The first mailing of invitations to INCOSE International Workshop 1999 was completed on October 21. An e-mail reminder was sent November 22. Some clarifications are in order. Credit cards are being accepted only for foreign attendees. The registration fee is $275. It will cost an additional $40 if you are bringing a guest to the banquet; otherwise the banquet is included in your registration price.

Invitations continue to be mailed as requested. The registration form is also available on our web site at http://incose.org/cazc. The names of those receiving invitations, date the invitation was mailed, and a confirmation indicator are also listed on the web site. If you are on the list but have not received an invitation please contact Cassandra Fleetwood at 602-929-5584 or at cassandra.fleetwood@medtronic.com. If you are interested in attending please contact the appropriate committee chair.

If they have not done so, committee chairs need to contact me to reserve meeting rooms. I need to know your preferred meeting days/times and number of attendees. I can be reached at (602) 436-5126 or Joseph.Juarez@CAS.honeywell.com. Also, check the web site (http://incose.org/cazc) for the most current master agenda.

Start-Up Queensland Australia Chapter Inaugural Meeting

Bill Parkins, Bill.parkins@boeing.com

SESA & INCOSE Reaching Out

The inaugural meeting of the Queensland State Chapter of SESA was held in the Customs House in Brisbane Friday, November 13, 1998. The meeting was hastily arranged during the previous week at the SE'98 conference in Canberra, which was attended by INCOSE President, Bill Schoening. We used company connections to induce Bill to interrupt his holiday on the Barrier Reef off Cairns in North Queensland to call in to Brisbane before heading home. This provided us with a golden opportunity to launch the new chapter.

The meeting was attended by 24 people and 10 apologies were received. Given the short time to arrange the meeting it appears there is a sufficient number of people interested in systems engineering to get the chapter off the ground. On behalf of the SESA National Committee, I gave a presentation on the mission and roles of SESA, and its relationships to the Institution of Engineers Australia (IE Aust) and INCOSE. The need to appoint an interim committee was addressed, with particular emphasis on the first year's program of activities in 1999. During and since the meeting there have been volunteers for the key positions on the interim committee, so we are off and running!

John D'Souza from IE Aust told us about the Institution's services, facilities available to the SESA chapter, entry qualifications, graduate training, National Register and the Engineering on Line (EOL) website. Bill Schoening addressed the meeting discussing a range of topics including the CMM Integration framework, impressions of the SE '98 conference, and his view on the ability of SESA to stage the INCOSE Symposium in the year 2001. Bill also mentioned the Systems Engineering Handbook, ***INSIGHT*** newsletter and Systems Engineering Journal. Questions were fielded on the role of students in INCOSE, CMM and EIA-632.

An e-mail list of attendees was made for follow-up. Thanks to Boeing Australia for sponsoring the event and to Tom Fordyce and Belinda Giles for the arrangements. Special thanks to Bill Schoening for his excellent talk.

We will keep you informed on the SESA home page of the progress of the new chapter:

www.adacel.com.au/SESA

Heartland Chapter

Steven Wolf, Treasurer,
sawolf@collins.rockwell.com

As we look forward to 1999, the Heartland Chapter celebrates its second year of existence. The new year will bring many challenges to our Chapter as we continue to grow our programs and stabilize our membership. The greatest of these challenges will be to mobilize our 60-member organization to help prepare for the INCOSE 2000 Summer Symposium. Our Chapter is looking forward to joining our friends in the Twin Cities North Star Chapter to make INCOSE 2000 an exciting experience.

In our short history, the Heartland Chapter has already enjoyed a host of interesting systems engineering speakers, discussing topics ranging from tools to methodologies, from requirements analysis to integration, and from systems engineering theory to applications. The Chapter was recently privileged to tour the local Duane Arnold Energy Center, a nuclear plant that has been successfully operating for 22 years. This outing generated enough interest and enthusiasm that a follow-on tour will be conducted next year. We thank our Programs Committee for giving us a great year of systems education.

Contributing to the success and promotion of our Chapter, the Communications Committee has published quarterly newsletters, complete with pictures and graphics, letters from our president, and highlights from INCOSE International. Additionally, Chapter meeting announcements and upcoming events have been printed in local newspapers, on web pages, and distributed through e-mail.

Our Membership Committee has already captured goals and objectives for the next few years and will soon begin their implementation. The initial membership consisted of primarily Rockwell Collins employees, but now our membership is diversifying to other companies around Cedar Rapids.

As a Chapter, we have looked for ways to join with other professional organizations in promoting engineering technology. Our Chapter has twice supported the local IEEE Chapter in its Fallcon Technical Conference in Cedar Rapids and will continue to do this in the years ahead. We have brainstormed ways to get into the community and involved with area youth and are now researching technical programs and events that have been successfully implemented in other cities.

As we close out 1998, we thank our founding president, Amy Nowakowski, for taking on the responsibilities and growing pains of a new Chapter. In 1999, Amy will pass the leadership baton to Robert "Jake" Jakoubek in the race toward INCOSE 2000.

The Heartland Chapter is always interested in hearing from other Chapters. If you know of something unique or interesting that you have tried, please let us know. Also, if you are in the Cedar Rapids area on the third Thursday of a month, please contact us for a visit.

Israel Chapter Forming

Dr. Moshe Weiler, m_weiler@inter.net.il

In October 1998, a group initiated activities for an Israeli start-up chapter, hosted by the Faculty of Aerospace Engineering at the Technion–Israel Institute of Technology. Our first event was in November 1998 when we held a one-day seminar about systems engineering in Israel. There were more than 150 participants from various industries and from the Israeli Defense Forces. The main topic on the agenda was the new Master's Degree in Systems Engineering. This program will begin in February 1999 at the Technion, led by Prof. Aviv Rozen, Aerospace Engineering Faculty Dean, and will be the first multi-disciplinary program of its kind to be held in Israel. Concluding our seminar, we had a panel that was conducted by the ex-Minister of Defense, Prof. Moshe Arens, dealing with education in systems engineering.

If you are interested in participating in this chapter, please contact me.

German Chapter Calendar of Events

Herbert Negele, h.negele@lrt.mw.tu-muenchen.de

The technical program of the German Chapter is planned for early 1999. The dates and times are confirmed for all, though there is a topic and speaker for the first event only. For updated information, be sure to visit the German Chapter Web site, as listed below.

January 19:
- Topic: "Einführung in TRIZ - Eine Methodik zur innovativen Systementwicklung" (Introduction to TRIZ - A Methodology for Innovative Systems Development)
- Speaker: Dipl.-Ing. Armin P. Schulz, Institute of Astronautics, Technical University of Munich
- Time: 6:00 PM

March 2:
- Topic and Speaker to be determined
- Time: 6:00 PM

April 13:
- Topic and Speaker to be determined
- Time: 6:00 PM

For all presentations:
- Place: TU München, Fachgebiet Raumfahrttechnik, Boltzmannstr. 15, 85748 Garching (near Munich)
- Contact: Herbert Negele, +49-89-289-16008, h.negele@lrt.mw.tu-muenchen.de
- Website: http://incose.lrt.mw.tu-muenchen.de

INCOSE Infrastructure

1999 Founders Award

The Founders Award is presented at INCOSE's yearly symposium to a distinguished member of the organization who has made a major contribution to the field of Systems Engineering and to INCOSE.

Nominations can be made by any INCOSE member, and must include three references from other INCOSE members, one of whom is a past president. Nominations, together with a description of the nominee's major contribution to systems engineering and to INCOSE, should be submitted to the Honors and Awards Committee at the INCOSE central office by February 15, 1999 (see below for the address).

1999 Pioneer Award

The Pioneer Award is given to a distinguished individual or team, who, by their achievements in the engineering of systems, have contributed uniquely to major products or outcomes enhancing society or its needs. The criteria may apply to a single, outstanding outcome, or a lifetime of significant achievements in effecting successful systems.

Nominations can be made by any INCOSE member with three references, two of which must be INCOSE members. Nominations, together with a description of the nominee's achievements in systems engineering, should be submitted to the Honors and Awards Committee at the INCOSE Central Office by February 15, 1999.

Please send all award nominations to:

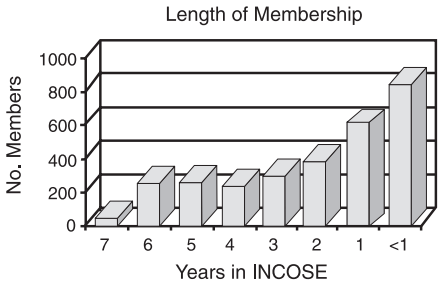
Honors and Awards Committee
INCOSE
2150 N 107th Street, Suite 205
Seattle, Washington 98133

You're in Good Company

Dona Lee, donalee@dynsys.com
Lew Lee, lew.lee@trw.com

The latest Membership Directory is available to all INCOSE members via download from the INCOSE web site (www.incose.org). We thought that it would be interesting to see what our membership database tells us about the demographics of our organization. Looking at the basic numbers, INCOSE has 2,849 members as of November 1998. Of the 2,849 members, 79 are students, and 12 consider themselves retired.

The last membership number assigned to a new member is 6157. This indicates that our retention is approximately forty-six percent over the past seven years. The chart below indicates that almost half of our current members are relative newcomers to INCOSE while nearly a third of the organization has been members for three years or more. In fact, fifty-six of the original one hundred charter members are still active in INCOSE.



Examining the professional affiliation of our members provides some interesting observations. The top organizations with ten or more INCOSE members are listed below. Affiliates are grouped together to simplify reporting. The number of members is indicated in parentheses. Those organizations that are also Corporate Advisory Board (CAB) members are highlighted. There are more than one hundred-sixty companies with two to ten employees who hold membership in INCOSE. Although many of these companies develop defense and aerospace systems, companies like Cable & Wireless, Eastman-Kodak, Fidelity Investments, Ford, General Motors, Qualcomm, and Siemens are also represented.

Leading Companies within INCOSE

1. **AlliedSignal** (11)
2. **Boeing** (24)
3. British Aerospace (22)
4. **GEC Marconi** (15)
5. **Hughes** (10)
6. **Litton** (15)
7. **Lockheed Martin** (52)
8. NASA (14)
9. Naval Air Systems Command/ Naval Air Warfare Center (12)
10. **Naval Surface Warfare Center** (11)
11. **Northrop Grumman** (10)
12. **Raytheon** (22)
13. **TRW** (20)
14. US Army (10)

We also looked at job titles to get some sense of the type of work our members are responsible for doing. For over eleven hundred members, "engineer" appears in their job title; for over seven hundred, the word "system" appears. Some of the top job titles are listed below.

Leading Job Titles

1. CEO/Owner/President
2. Chief Engineer
3. Consultant/Consultant Engineer
4. Director/Deputy Director
5. Manager
6. Principal Engineer/Principal Systems Engineer

7. Assistant Professor/Associate Professor/Professor
8. Program Manager/Project Manager
9. Senior Engineer/Senior Systems Engineer
10. Systems Engineer/General Engineer/Engineer
11. Senior Systems Engineering Manager
12. Vice President

What this shows is that a significant segment of the INCOSE membership are the people responsible for the operations of their organizations and projects. These are the people who have decision-making responsibilities that can spell success or failure on their projects.

By design, INCOSE was intended as a forum to enable participants to succeed in the realization of successful systems. The data presented shows that INCOSE is reaching its intended audience. INCOSE's challenge is to continue to expand its influence to industries outside of systems engineering's traditional domain of aerospace and defense.

SECOE Project Measuring Systems Engineering Effects

Eric Honour, ehonour@hcode.com

The virtual INCOSE Systems Engineering Center of Excellence (SECOE) is coordinating a project to measure and correlate the effects of systems engineering on project success. The Systems Engineering Effects project 98-01 is funded by participating companies in a uniquely synergistic combination of research and benchmarking services. Researchers use protected project data in return for quarterly reports that show how each project measures up against other projects and other companies.

From a research viewpoint, the project is designed to test the broadly held hypothesis that systems engineering contributes to system success. Data gathered is of three types:

- System engineering effort, measured by quarterly effort and cost expended in systems engineering tasks. Initially, the tasks are limited to four: requirements management, system architecting, risk management, and system technical analysis.
- Project Success Measures. Success is measured by financial return on investment, project profit and customer satisfaction.
- System Project Characterization. A series of parameters provide insight into the types and classes of correlation to be found. Parameters include descriptive quantities such as number of system elements, subjective system measures such as desired reliability level, and subjective team measures such as system analyst experience.

Based on the widely known heuristic knowledge, research expects to find a peak level of systems engineering effort that contributes to system project success. It is also expected that the peak will vary dependent on the character of the system projects.

From a benchmarking viewpoint, the project provides quarterly reports to each participating company and project. The reports provide effective information for internal process comparison and improvement. Protected information is provided only to the source company, while all companies receive the statistical basis. The quarterly data includes:

- *Source Data*. Original data obtained during the data gathering (protected data);
- *Benchmarking*. Comparison of source data against the statistical distribution of all data, by project types and characteristics, and by industry;
- *Trending*. Comparison of source data against prior project data and against other company projects;
- *Correlation Results*. Statistic implications on systems engineering effectiveness, by project types and characteristics, and by industry;
- *Process Improvements*. Suggestions for specific process improvements implied by the data.

SECOE is still seeking additional participating companies. Cost of the project for each company is significantly less than other benchmarking services. The service provides quarterly reports rather than a single snapshot, and it provides data specific to the systems engineering aspects of the project.

SECOE is an INCOSE-sponsored, U.S.-based association of over 30 universities dedicated to research into complex systems development. It is one element of an international Network of Excellence that also includes the UK-based STEFFIE and other burgeoning efforts. SECOE is continuing to develop further projects and funding proposals to connect researchers with potential research funds in accordance with a broad systems engineering oriented research agenda. See the SECOE web site at http://www.secoe.org for more information.

1998 Election Results

Eric Honour, ehonour@hcode.com

The 1998 INCOSE elections were conducted in October and I am pleased to announce the result. My congratulations are extended to each of the newly-elected members of the INCOSE Board of Directors:

President-Elect	Donna Rhodes
Secretary	Judith Peach
Director-at-Large	Peter Brook
Region I Director	Ken Crowder
Region II Director	Elliot Axelband
Region III Director	Terje Fossnes
Region IV Director	Don Clausing
Region V Director	Harry Crisp
Region VI Director	David Watt

I also wish to thank each of the following leaders who extended their willingness to serve INCOSE. Although not elected to the Board this year, I expect that we will continue to see them active in various roles.

Brian McCay
Jas Madhur
William Wells
Eduard Igenbergs
Robert Bailey
Herve Rochecouste

In addition, I wish to thank the volunteer members of the Nominations Committee, who gave much of their time to identify and foster the advancement of these leaders:

John Clouet
Pat Hale
Fariba Hozhabrafkan
Tom Kabaservice
Ken Ptack

Please join me in welcoming each of the new and returning directors in their success.

People on the Move

Loyd Baker has recently joined 3SL as Vice President of Systems Engineering. Loyd heads the 3SL Southeast Region Office, and will direct U.S. technical sales, training and consulting services for the Cradle toolset. Contact Loyd at loyd.baker@threesl.com or (256) 722-5020.

Karen Kelley has accepted a position as the Chief Architect of the System Engineering Process Group for The Vanguard Group, in Valley Forge, Pennsylvania. You can reach Karen at karen_kelley@vanguard.com, or (610) 669-8499.

Fred Knopf has recently joined 3SL, developers of the Cradle Systems Engineering Environment. As Vice President of U.S. Operations, Fred is responsible for U.S. marketing, sales and support services associated with the Cradle product line. He can be reached at fred.knopf@threesl.com, or phone (301) 570-6120.

Corporate Advisory Board Member Companies

Aerojet

The Aerospace Corporation

AlliedSignal, Inc.

Ascent Logic Corporation

The Boeing Military Aircraft & Missile Systems

The Boeing Company

C.S. Draper Laboratory, Inc.

DaimlerChrysler Aerospace/ AG Dornier Sattellitensysteme GmbH

Delphi Automotive Systems

GEC Marconi

Honeywell, Inc.

Litton/PRC, Inc.

Lockheed Martin Corporation

MITRE Corporation

Motorola

Naval Surface Warfare Center, Dahlgren Division

Northrop Grumman Corp.

Raytheon Systems Company/HAC

Raytheon Systems Company/RES

Raytheon Systems Company/RTIS

Rockwell Collins

Science Applications International Corporation

TRW

United Technologies

U.S. Department of Energy–Idaho

Industry News

International System and Software Standards Update

Dr. Jerry Lake, lakejg@mindspring.com

Published ISO standards can be obtained from the American National Standards Institute (ANSI). Working Drafts (WDs) of ISO standards are only available for working group review and use. Once approved, the working group releases a Committee Draft (CD). This version is available for all working groups of SC7 to review and comment. Once the CD is approved by SC7, a Draft International Standard (DIS) is prepared and balloted. A successful ballot results in publication of the International Standard.

Working Group 7 (WG7) of the International Organization for Standards JTC1 Subcommittee 7 (SC7) met in Curitiba, Brazil during November 1998. Dr. Jerry Lake represents INCOSE on the SC7 Life Cycle Management Working Group (WG7). Other INCOSE members attending the meeting were: Mr. Matthew Young (Australia-SESA), Mr. Alain Faisandier (France), Dr. Harold Lawson (Sweden), Mr. Stuart Arnold (UK-Editor 15288), Mr. Richard Schmidt (US- Editor 15288), and Mr. Richard Schwadron (US). The following is Dr. Lake's report on the meeting.

The following nations participated in the WG7 meeting—Australia, Brazil, France, Germany, Israel, Japan, South Africa, Sweden, United Kingdom, and United States.

Four international standards are the focus of WG7. The actions taken on these were:

1 Revision of ISO/IEC 12207 *Software Life Cycle Processes*. Ballot comments on the Project Requirements for the revision of the 12207 standard were acted on at this meeting. This standard was published in 1995. The project requirements are segregated in two categories: those for the proposed amendment and those for the proposed revision. The first is to provide an amendment update to 12207 by the year 2000. The second is to provide a rewrite of 12207 to be consistent with ISO/IEC 15288 when that systems standard is published. The letter ballot on the project was successful. Ballot comments were resolved by a special working group (OWG) of WG7, including a liaison from WG10 (capability maturity models working group). A comment resolution report and an updated set of Project Requirements were prepared for passage to SC7. The 12207 Editor will prepare a project plan and development schedule for the Amendment so that work on the amendment can be initiated by the next WG7 meeting in May 1999.

2 ISO/IEC 14759 *Mockup and Prototype*. A final comment resolution was reached and the Editor was asked to finalize the document for publication as an international standard.

3 ISO/IEC 14764 *Software Maintenance*. This standard is in Final Committee Draft (FCD). Comment resolution was conducted for comments received from the SC 7 Secretariat and National Bodies. Japan's comments were resolved satisfactorily and Japan changed its vote on the FCD to approval. Assuming that additional comments received by the ballot close indicate approval of the FCD, WG7 agreed that a revised document should be forwarded for FDIS (final draft international standard) ballot.

4 ISO/IEC 15288 *System Life Cycle Processes*. National Body comments on WD3 (working draft 3) were reviewed and discussed by the 20 systems-focused delegates, whilst 10 software delegates dealt with the other three standards. WD3 was judged by several to be a step backwards from the progress made in Johannesburg in May 1998. There was general dissatisfaction expressed by several system delegates on the changes made by the Editors on the inputs prepared by delegates at the Johannesburg meeting. Although most WD3 comments were expeditiously dealt with, eight issues surfaced that required resolution by the whole of WG7. A main issue was on the set of technical processes that was judged to be the most complete and adequate from the work in Johannesburg by French, U.K. and U.S. delegates. It was in this area that major changes were made by the Editors. Differing views with the Editors' list of technical processes were presented by various national Heads of Delegation (HODs). The Editors were instructed to consider these differing views during their preparation of WD4 (working draft 4). In addition, the following was agreed by resolution:

(a) The term "stages" be used instead of "phases" or "states" to describe life cycles.

(b) That ISO/IEC 15288 contain a requirement to establish a system life cycle model for the project i.e., "A system life cycle model shall be established for the project."

(c) The descriptions of the life cycle stages are to be informative only.

(d) That the process outlines will contain (1) name of process, (2) purpose, (3) outcomes, and (4) activities with PDCA (plan, do, check, act).

Significant dates for ISO/IEC 15288 are:

- **27 January 1999** – Distribution of WD4 to HODs,
- **1 March 1999** – Comments on WD4 to Editors and other HODs
- **22-26 March 1999** – WG7 meeting in Tel Aviv, Israel with WG10
- **1 May 1999** – WD5 distributed to HODs
- **10 May 1999** – Comments on WD4 to Editors and other HODs
- **24-28 May 1999** – SC7/WG7 meeting in Curitaba, Brazil

ANNOUNCEMENT: Thirteenth Annual
International Conference on Systems Engineering (ICSE)

THE MANY FACES OF SYSTEMS ENGINEERING

August 9-12, 1999

This series of conferences has been jointly organized and sponsored on a rotational basis by the University of Nevada Las Vegas, USA, the Technical University of Worclaw, Poland and Coventry University, United Kingdom. The 13th Annual Conference is co-sponsored by the Silver State Chapter of INCOSE and will be held at the Orleans Hotel & Casino in Las Vegas, Nevada.

■ SCOPE OF CONFERENCE:

- Avionics
- Computer Algorithms, Databases, Parallel and Distributed Systems and Networks
- Control Theory, System Identification, Adaptive control, Nonlinear Controls
- Engineered Systems for Nuclear Waste
- Environmental and Energy Systems
- Expert Systems and Artificial Intelligence
- Geographic Information and Global Positioning Systems
- Information Theory and Communication Systems
- Standards and Testing
- Signal Processing
- System Architecture
- Systems Engineering Management, Metrics, Education, Paradigms, Standards and Challenges
- Requirements Processes
- Risk Management
- Robotics and Industrial Automation
- Neural Networks and Applications

■ CALL FOR PAPERS:

Submit paper abstracts (6 hard copies, or a single electronic MSWord file format, approximately 1000 words) before February 1, 1999. Abstracts should be typed (double space) in English.

■ ATTENTION EXHIBITORS:

This conference offers: 1) A fresh International audience of more than 300 Systems Engineering Professionals and Educators from Industry and Academia. 2) A well-equipped exhibit hall, located at the hub of the conference meeting rooms, forming a focal point for the attendees with a collocated lunch buffet and a reception the evening prior to the first day. 3) Advertising of your company services/products on CD-ROM proceedings of the conference. 4) An international contact list of all delegates attending ICSE. 5) A wide range of sponsorship and advertising opportunities throughout the conference. 6) Entry to all technical presentations. For more information, please contact the Exhibits Chair M. Sam Rindskopf at (702) 295-3965 or e-mail at m.sam_rindskopf@ymp.gov.

■ CALL FOR TUTORIALS:

Proposals should be submitted by February 1, 1999 in hard copy by mail, or soft copy in MSWord or RTF by e-mail. It should contain a technical abstract (no more than one page), course length (half or full day), detailed course outline, description of the targeted participant, what the participant should gain from the tutorial, and number of participants (min and max) for an effective tutorial. Include brief biographical sketch of the instructor(s), tutorial materials provided by the instructor and reproduction requirements. Also include a description of the main topic of the tutorial, background of the lecturers in this topic, where the tutorial has been presented before and its degree of success. Identify the Proposal Contact; include name, business affiliation, address, phone, fax and e-mail. For more information please contact Jesse Teal at (702) 295-4199 or by e-mail at Jesse_Teal@ymp.gov

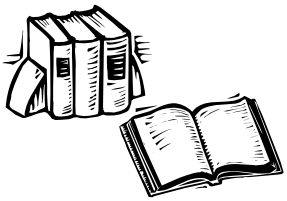
Conference fees are expected to be around $300.00 - $350.00 US.

Deadlines:

Abstracts and Proposed Invited Sessions	February 1, 1999
Acceptance of Papers	March 15, 1999
Submission of Full Papers	April 15, 1999

Submit INCOSE Abstracts and Invited Sessions proposals to:

Attention: Dr. Ovadia Lev, ICSE 99
TRW Environmental Safety Systems, Inc.
1261 Town Center Drive, Las Vegas, NV 89134
(702) 295-4057, ovadia_lev@ymp.gov



Book Reviews

The Whole Brain Business Book

by Ned Herrmann, McGraw-Hill, 1996
ISBN: 0-07-028462-8
Reviewed by Stanley E. Long

Last summer, in Lake Lure, North Carolina, I met some people who introduced me to the ideas in this book. Ned Herrmann's company, The Ned Herrmann Group, is based in Lake Lure. Herrmann has been an international consultant for over a decade in his "second" career. His first was at General Electric, where he developed his Whole Brain Technology theories. The book is a fascinating read, providing immediate insight into the business of how people work and communicate. It is good for self-analysis as well as providing insight into such questions as:

- Why do peers always criticize your presentations?
- Why does your boss never read your reports?
- Why does "brainstorming" work?
- Why is it so difficult to make a user-friendly system?
- Why do bright people sometimes fail at relatively simple tasks?
- What makes a person enjoy work?

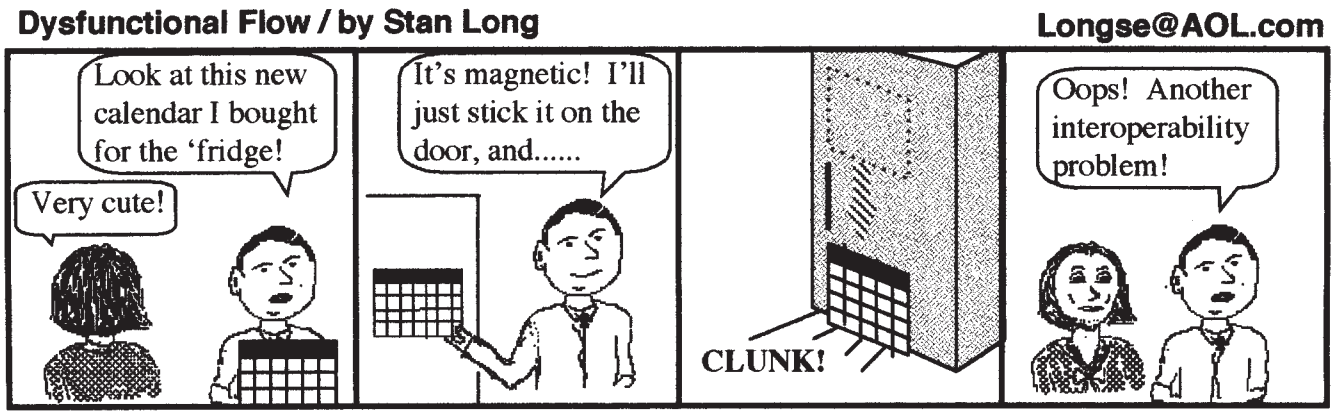
Answers to these and many other questions related to thinking behavior are buried in this easy-to-read book describing Herrmann's research on brain dominance theory.

In contrast to the right brain, left brain model, Herrmann developed a Whole Brain Model, which characterizes human thinking in terms of four quadrants, or thinking preferences. They are: A-Analyzer, B-Organizer, C-Personalizer, and D-Visualizer. His studies indicate that, at an early age, we all develop thinking preferences dominated by one of these quadrants. These preferences shape our interests, and determine what kinds of work we like and dislike. Herrmann developed an assessment tool, called the Herrmann Brain Dominance Instrument (HBDI), which is capable of quantifying the degree to which a person's individual preferences fit these quadrants. Given this, the best problem-solving approach applies Whole Brain thinking by gathering together enough diverse people to focus on the problem, so that together they produce a Whole Brain solution.

A key concept is the relationship of thinking preferences to jobs, and why a person may do well at some tasks and poorly at others. For example, Herrmann explains why an A-quadrant engineer may be very unhappy and not do well when placed in a C-quadrant, people-oriented job, such as first-level management. Similarly, a B-quadrant supervisor is not likely to succeed in a D-quadrant Visualizer job, such as marketing or new product development.

Another fascinating part of this book describes how organizations or teams may be aligned to produce a Whole Brain culture. Herrmann gives an example of the Boeing 777 airliner as a "whole brain product," user-friendly to the passengers, the airline, and the crew. He also talks about the impact of creativity and innovation on organizations, and how to stimulate "out of box" thinking in groups.

This book should definitely be on the systems engineer's reading list. Don't let the word "business" in the title fool you. This book applies to engineering, and to any field where the goal is to provide the best possible product or system.



Do you have ideas for Stan's next cartoon? Contact him at longse@aol.com

INCOSE '99 Update

Peter Robson, Symposium General Chair, peter.robson@baedsl.co.uk

In the last ***INSIGHT***, we shared with you the material that we brought to Vancouver with the main objective of encouraging an entry in next year's calendar. Good–you've all done that!

For this issue, let us try to give you a brief update of how our plans are coming along. Already we are confident that INCOSE '99 will have an excellent overall content. We have more papers submitted, more tutorials proposed and more panels suggested than we expected! Wow! This is going to cause some headaches for the Technical Program Committee! More time is being allocated for tutorials so that you can benefit from the excellent range of subjects that have been proposed. We were worried that the glitch over the paper submission date (when we slipped it from October 2 to November 16) was going to cause a problem–no way! So, thanks at this stage to all those who are working with us to make INCOSE '99 a success.

An invitation pack has gone to all vendors and other exhibitors on our list; this list is a consolidation of the Los Angeles ('97) and Vancouver ('98) contacts together with the lists from previous UK/European events. (If your organisation has not received an invitation and would like further details, please contact the Exhibits Chair, Jane Smith at jes@cs.york.ac.uk.)

As information becomes available, it is placed on our web site and may be accessed via www.incose.org.uk. A full site for the event is under construction and should be available by the time you receive this issue of ***INSIGHT***. Cass Jones from Professional Conference Management Inc., INCOSE's Symposium Services Provider, is beavering away on travel arrangements to help you get to Brighton more easily and cheaply! Keep a watch on the site because this and other useful information may well appear there first.

Our next major deliverable is the INCOSE '99 Brochure that forms the major mailing for the event. This is a real challenge because the Symposium is in mid-June rather than at its normal time of late July/early August whilst the International Workshop (at which the details are given the final okay) is at its usual time at the end of January! Work on the brochure started in October but a major part of the content is the detailed program that is heavily dependent on the paper review process, which is starting mid-November. Our reviewers will be working hard so that the brochure can be finalized and in your hands before the end of February.

'Brighton' your Systems Engineering in '99!—see you there!

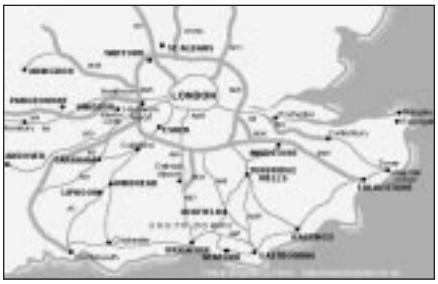
So, where IS Brighton exactly?

Ian Sedgley, ian.sedgley@bae.co.uk

It didn't sound like a trick question and I really ought to have been able to answer. I was, after all, the man on the INCOSE '99 stand in Vancouver.

I've read all the other accounts of Vancouver in the Fall issue of ***INSIGHT***. Full of words like "superb, inspirational, exciting, comprehensive, smashing and the very best ever." Apparently no one but me had the bottom drop out of his or her little world. I know where Brighton is. Drive south out of London on the A23 and stop when you reach the English Channel. Take a train or a bus. Cycle or rollerblade if you wish, jog if you must, you can't miss it. It's been a popular watering hole since the Prince Regent (later King George IV) first visited in 1783. Some 215 years later the INCOSE '99 logo includes a silhouette of his fantastic seaside palace, the Royal Pavilion, with its Indian domes and minarets. The logo also incorporates a view of the south coast of England with a shooting star clearly landing in Brighton.

So why the cold sinking feeling? Because I knew with absolute certainty that no matter how many times I scrabbled through the cardboard boxes beneath the table I wasn't going to find what I needed. There wasn't one in there. We hadn't packed one. The one thing we needed above all else—a map. With the aid of a postage stamp sized illustration on a leaflet I explained very carefully to the enquirer exactly how to find Brighton. I'm not entirely convinced we'll see her next June. Somewhere in downtown Vancouver there had to be a map of the old country, and Cass and Christine (from PCMI, the organizers for the Brighton symposium) were in no mood to be denied. They did find one. A very interesting example of tourist cartography that showed all



the major cities and towns. The thing that made it interesting was that most of them were in the wrong location!

We made some red pen adjustments to Brighton and ignored the rest. I don't think anyone noticed. Fortunately for all of us there is a much clearer (and more accurate) map plus lots more useful informa-

tion on the Brighton Web site– www.brighton.co.uk.

I think whoever wrote the publicity material on the site has probably attended one or two symposiums. "There's nothing quite like a bracing walk along the prom or a stroll out to sea on the Palace Pier to clear heads and revive appetites" it says. And that raises another question, what is a "prom" or indeed a "pier?" Don't bring your dancing shoes, it's not that sort of prom, it's a promenade. You'll be there in the early summer when the evenings, El Ninõ permitting, should be pleasantly mild and ideal for strolling the sea front of our most traditional holiday resort. Jutting out into the sea are the two piers. The larger of the two, the Palace Pier, is an impressive and interesting stroll among amusements and curio stalls while the other, the West Pier, could well be ideal if you enjoy watching other people work — it's currently being refurbished. The aim is to restore it to its former glory and standing as an architectural and historically significant structure.

While preparing this I've been popping in and out of various web sites (there's another at www.sussex-tourism.org.uk) and a great idea has occurred to me, though too late as usual. I should simply have taken my laptop into the Hotel Vancouver and hooked into the Net. I could have accessed maps, history, pictures, theatre programmes, weather and transport timetables.

Even that might not have helped me with the second tricky question. A gentleman this time. "So, tell me," he said, "where is England? I mean, what is it close to?"

Systems Engineering: The Journal of The International Council on Systems Engineering

Call for Papers

The ***Systems Engineering*** journal is intended to be a primary source of multidisciplinary information for the system engineering and management of products and services, and processes of all types. System engineering activities involve the technologies and system management approaches needed for:

- **definition of systems**, including identification of user requirements and technological specifications;
- **development of systems**, including conceptual architectures, tradeoff of design concepts, configuration management during system development, integration of new systems with legacy systems, integrated product and process development; and
- **deployment of systems**, including operational test and evaluation, maintenance over an extended lifecycle, and reengineering.

The ***Systems Engineering*** journal is the archival journal of, and exists to serve the following objectives of, the **International Council on Systems Engineering** (INCOSE).

- To provide a focal point for dissemination of systems engineering knowledge.
- To promote collaboration in systems engineering education and research.
- To encourage and assure establishment of professional standards for integrity in the practice of systems engineering.
- To improve the professional status of all those engaged in the practice of systems engineering.
- To encourage governmental and industrial support for research and educational programs that will improve the systems engineering process and its practice.

The Journal supports these goals by providing a continuing, respected publication of peer-reviewed results from research and development in the area of systems engineering. Systems engineering is defined broadly in this context as an interdisciplinary approach and means to enable the realization of successful systems that are of high quality, cost-effective, and trustworthy in meeting customer requirements.

The ***Systems Engineering*** journal is dedicated to all aspects of the engineering of systems: technical, management, economic, and social. It focuses on the life cycle processes needed to create trustworthy and high quality systems. It will also emphasize the systems management efforts needed to define, develop, and deploy trustworthy and high quality processes for the production of systems. Within this, ***Systems Engineering*** is especially concerned with evaluation of the efficiency and effectiveness of systems management, technical direction, and integration of systems. ***Systems Engineering*** is also very concerned with the engineering of systems that support sustainable development. Modern systems, including both products and services, are often very knowledge intensive, and are found in both the public and private sectors. The Journal emphasizes strategic and program management of these, and the information and knowledge base for knowledge principles, knowledge practices, and knowledge perspectives for the engineering of systems. Definitive case studies involving systems engineering practice are especially welcome.

The Journal is a primary source of information for the systems engineering of products and services that are generally large in scale, scope, and complexity. ***Systems Engineering*** will be especially concerned with process or product line related efforts needed to produce products that are trustworthy and of high quality, and which are cost effective in meeting user needs. A major component of this is system cost and operational effectiveness determination, and the development of processes that assure products that are cost effective. This requires the integration of a number of engineering disciplines necessary for the definition, development, and deployment of complex systems. It also requires attention to the lifecycle process used to produce systems, and the integration of systems, including legacy systems, at various architectural levels. In addition, appropriate systems management of information and knowledge across technologies, organizations, and environments is also needed to insure a sustainable world.

The Journal will accept and review submissions in English from any author, in any global locality, whether or not the author is an INCOSE member. A body of international peers will review all submissions, with potential author revisions as recommended by reviewers, with the intent to achieve published papers that:

- Relate to the field of systems engineering
- Represent new, previously unpublished work
- Advance the state of knowledge of the field
- Conform to a high standard of scholarly presentation

Editorial selection of works for publication will be made based on content, without regard to the stature of the authors. Selections will include a wide variety of international works, recognizing and supporting the essential breadth and universality of the field. Final selection of papers for publication, and the form of publication, shall rest with the Editor.

The journal will begin quarterly publication at the beginning of the second quarter of 1998 and four issues are anticipated in 1998. Submission of quality papers for review is strongly encouraged. The review process is estimated to take three to five months. Five copies of your manuscript should be submitted for review purposes to:

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